THE BUREAU OF STANDARDS

SERVICE MONOGRAPHS
OF THE
UNITED STATES GOVERNMENT
NO 35
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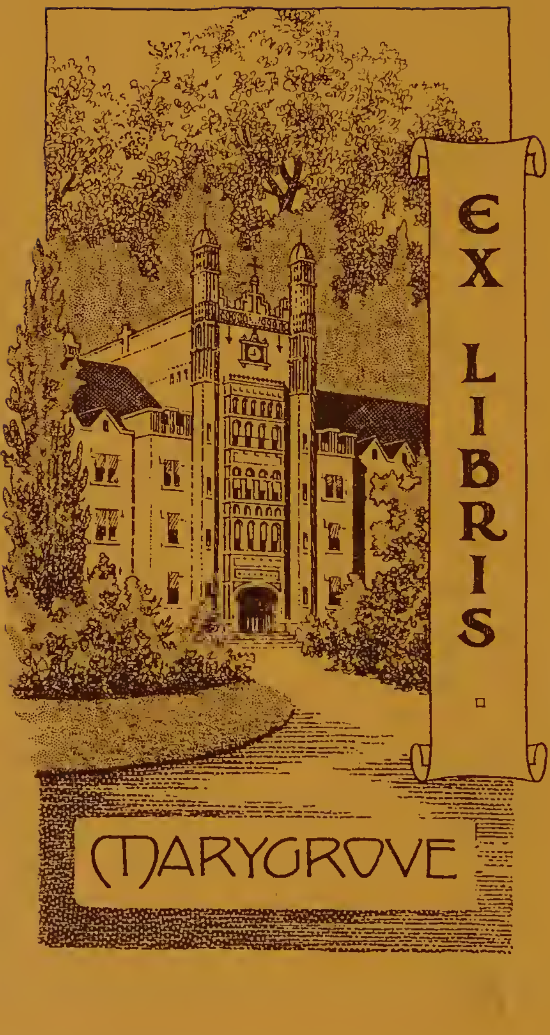
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THE BUREAU OF STANDARDS

ITS HISTORY, ACTIVITIES AND ORGANIZATION

THE INSTITUTE FOR GOVERNMENT RESEARCH
Washington, D. C.

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SERVICE MONOGRAPHS
OF THE
UNITED STATES GOVERNMENT
No. 35

THE BUREAU OF STANDARDS

ITS HISTORY, ACTIVITIES AND ORGANIZATION

BY
GUSTAVUS A. WEBER

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FOREWORD

The first essential to efficient administration of any enterprise is full knowledge of its present make-up and operation. Without full and complete information before them, as to existing organization, personnel, plant, and methods of operation and control, neither legislators nor administrators can properly perform their functions.

The greater the work, the more varied the activities engaged in, and the more complex the organization employed, the more imperative becomes the necessity that this information shall be available—and available in such a form that it can readily be utilized.

Of all undertakings, none in the United States, and few, if any, in the world, approach in magnitude, complexity, and importance that of the national government of the United States. As President Taft expressed it in his message to Congress of January 17, 1912, in referring to the inquiry being made under his direction into the efficiency and economy of the methods of prosecuting public business, the activities of the national government "are almost as varied as those of the entire business world. The operations of the government affect the interest of every person living within the jurisdiction of the United States. Its organization embraces stations and centers of work located in every city and in many local subdivisions of the country. Its gross expenditures amount to billions annually. Including the personnel of the military and naval establishments, more than half a million persons are required to do the work imposed by law upon the executive branch of the government.

" This vast organization has never been studied in detail as one piece of administrative mechanism. Never have the foundations been laid for a thorough consideration of the relations of all of its parts. No comprehensive effort has been made to list its multifarious activities or to group them in such a way as to present a clear picture of what the government is doing. Never has a complete description been given of the agencies through which these activities are performed. At no time has the attempt been made to study all of these activities and agencies with a view to the assignment of each activity to the agency best fitted for its performance, to the avoidance of duplication of plant and work, to the integration of all administrative agencies of the government, so far as may be practicable, into a unified organization for the most effective and economical dispatch of public business."

To lay the basis for such a comprehensive study of the organization and operations of the national government as President Taft outlined, the Institute for Government Research has undertaken the preparation of a series of monographs, of which the present study is one, giving a detailed description of each of the fifty or more distinct services of the government. These studies are being vigorously prosecuted, and it is hoped that all services of the government will be covered in a comparatively brief space of time. Thereafter, revisions of the monographs will be made from time to time as need arises, to the end that they may, as far as practicable, represent current conditions.

These monographs are all prepared according to a uniform plan. They give: first, the history of the establishment and development of the service; second, its functions, described not in general terms, but by detailing its specific activities; third, its organization for the handling of these activities; fourth, the character of its plant; fifth, a compilation of, or reference to, the laws and regulations governing its operations; sixth, financial statements showing its appropriations, expenditures and other data for a period of years; and finally, a full bibliography of the sources of information, official and private, bearing on the service and its operations.

In the preparation of these monographs the Institute has kept steadily in mind the aim to produce documents that will be of direct value and assistance in the administration of public affairs. To executive officials they offer valuable tools of administration. Through them, such officers can, with a minimum of effort, inform themselves regarding the details, not only of their own services, but of others with whose facilities, activities, and methods it is desirable that they should be familiar. Under present conditions services frequently engage in activities in ignorance of the fact that the work projected has already been done, or is in process of execution by other services. Many cases exist where one service could make effective use of the organization, plant or results of other services had they knowledge that such facilities were in existence. With the constant shifting of directing personnel that takes place in the administrative branch of the national government, the existence of means by which incoming officials may thus readily secure information regarding their own and other services is a matter of great importance.

To members of Congress the monograph should prove of no less value. At present these officials are called upon to legislate and appropriate money for services concerning whose needs and real problems they can secure but imperfect information. That the possession by each member of a set of monographs such as is here projected, prepared according to a uniform plan, will be a great aid to intelligent legislation and appropriation of funds can hardly be questioned.

To the public, finally, these monographs will give that knowledge of the organization and operations of their government which must be had if an enlightened public opinion is to be brought to bear upon the conduct of governmental affairs.

These studies are wholly descriptive in character. No attempt is made in them to subject the conditions described to criticism, nor to indicate features in respect to which changes might with advantage be made. Upon administrators themselves falls responsibility for making or proposing changes which will result in the improvement of methods of administration. The primary aim of outside agencies should be to emphasize this responsibility and facilitate its fulfillment.

While the monographs thus make no direct recommendations for improvement, they cannot fail greatly to stimulate efforts in that direction. Prepared as they are according to a uniform plan, and setting forth as they do the activities, plant, organization, personnel and laws governing the several services of the government, they will automatically, as it were, reveal, for example, the extent to which work in the same field is being performed by different services, and thus furnish the information that is essential to a consideration of the great question of the better distribution and coördination of activities among the several departments, establishments, and bureaus, and the elimination of duplications of plant, organization and work. Through them it will also be possible to subject any particular feature of the administrative work of the government to exhaustive study, to determine, for example, what facilities, in the way of laboratories and other plant and equipment, exist for the prosecution of any line of work and where those facilities are located; or what work is being done in any field of administration or research, such as the promotion, protection and regulation of the maritime interests of the country, the planning and execution of works of an engineering character, or the collection, compilation and publication of statistical data, or what differences of practice prevail in respect to organization, classification, appointment, and promotion of personnel.

To recapitulate, the monographs will serve the double purpose of furnishing an essential tool for efficient legislation, administration and popular control, and of laying the basis for critical and constructive work on the part of those upon whom responsibility for such work primarily rests.

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THE BUREAU OF STANDARDS

ITS HISTORY, ACTIVITIES, AND ORGANIZATION

CHAPTER I

HISTORY

The functions of the Bureau of Standards of the Department of Commerce, as briefly defined by the Director,[1] "comprise the development, construction, custody, and maintenance of reference and working standards, and their intercomparison, improvement, and application in science, engineering, industry, and commerce." The functions of its predecessor, the Office of Standard Weights and Measures of the Treasury Department were concerned mainly with such of the standards of weights and measures as relate to length, mass, and capacity. The early part of the present history, therefore, deals entirely with that subject.

Early Efforts to Establish Standard Weights and Measures. The subject of uniform standards of weights and measures occupied the attention of the colonies long before the formation of the present national government. The weights and measures in use by the colonies were nearly all of English origin. Copies of the English standards of the yard, avoirdupois pound, gallon, and bushel had been brought over at various times and adopted by the different colonies. In Louisiana the weights and measures were originally French, but soon after the Louisiana Purchase the weights and measures there were changed to conform to those of other states.

As there were considerable divergencies in these weights and measures, their lack of uniformity caused great inconvenience in the intercolonial business relations, and it was quite natural therefore, that, after the Declaration of Independence, the associated states should make some provision in the Articles of Confederation looking toward the establishment of a uniform standard. Thus, Article 9 of that instrument provided that "the United States in Congress assembled shall . . . have the sole and exclusive right and power of . . . fixing the standard of weights and measures throughout the United States." No legislation, however, was enacted by the Continental Congress providing such a standard.

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[1] Annual Report, 1922, Chart facing page 1.

While the Constitution of the United States was being drawn up the Constitutional Convention also took cognizance of the need for a uniform standard of weights and measures, and inserted in Article 1, Section 8, Clause 5 of the Constitution the provision giving Congress power "to fix the Standard of Weights and Measures."

Emphasis is given to the necessity for a uniform standard of weights and measures in Clause 1 of the same section, which provides that "all Duties, Imposts and Excises shall be uniform throughout the United States."

Recommendations of Executives and Congressional Committees. One of the earliest recommendations made by President Washington was for the establishment by law of uniform and reliable standards of weights and measures, and during his administration he several times urged the necessity for such legislation in communications to Congress. Thus in his first annual message, delivered on January 8, 1790, he said, "Uniformity in the currency, weights and measures of the United States is an object of great importance, and will, I am persuaded, be duly attended to"; and in his third annual message, delivered October 25, 1791, he said, "An uniformity in the weights and measures of the country is among the important objects submitted to you by the Constitution, and if it can be derived from a standard at once invariable and universal, must be no less honorable to the public councils than conducive to the public convenience."

In obedience to an order of the House of Representatives of January 15, 1790, Thomas Jefferson, then Secretary of State, made an elaborate report dated July 4, 1790, presented to Congress

July 13, 1790,[2] in which he suggested a plan for establishing uniformity in the coinage and in the weights and measures of the United States. He proposed a system whereby the measures and weights and coins "will be derived altogether from mechanical operations, viz.: a rod vibrating seconds . . . subdivided and multiplied . . . for every measure of length, surface and capacity and these last filled with water to determine the weights and coins."

The standard for measurement was to be "a uniform cylindrical rod of iron of such length as in latitude 45 degrees, in the level of the ocean and in a cellar or other place the temperature of which does not vary through the year, shall perform its vibrations in small equal arcs in one second of mean time." This standard rod was to be divided into 587⅕ equal parts, each of these parts being declared a line, which is one tenth of an inch.

The measure of capacity was to be based on the bushel of a cubic foot capacity in case a decimal system should be adopted, or a gallon of 270 cubic inches and a bushel of 2160 cubic inches if the old system was to be retained.

The unit of weight was to be an ounce, this being "the weight of a cube of rain water of one-tenth of a foot; or rather, that it is the thousandth part of the weight of a cubic foot of rain water weighed in the standard temperature."

In his plan he presented two alternatives; one was the placing of all divisions of weights and measures on a decimal basis, the other was "to define and render uniform and stable the existing system."

As to the method to be adopted for introducing a new system of weights and measures, Jefferson said, "a gradual introduction would lessen the inconveniences which might attend too sudden a substitution, even of an easier for a more difficult system. After a given term, for instance, it might begin in the customhouses, where the merchant would become familiarized to it. After a further term, it might be introduced into all legal proceedings, and merchants and traders in foreign commodities might be required to use it in their dealings with one another. After a still further term, all other descriptions of people might receive it into common use."[3]

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[2] American State Papers, Misc., Vol. I, p. 19.
[3] *Ibid.*

A subsequent report, or "postscript" by Jefferson, dated January 17, 1791, made certain corrections in the original report.

The Senate committee of the First Congress, to which Jefferson's report had been referred, made the following comment in its report of March 1, 1791:[4] "That, as a proposition had been made to the National Assembly of France for obtaining a standard of measure, which shall be invariable and communicable to all nations, and at all times; as a similar proposition has been submitted to the British Parliament, in their last session; as the avowed object of these is to introduce a uniformity in the measures and weights of commercial nations as a coincidence of regulation, by the Government of the United States, on so interesting a subject would be desirable, your committee are of opinion that it would not be eligible, at present, to introduce any alteration in the measures and weights which are now used in the United States."

The House committee to which was referred Jefferson's report of July 13, 1790, and the President's message of January 8, 1790, made a report on April 12, 1796, recommending that standard weights and measures be regulated and that scientific experiments be made by the government to fix upon a standard of weights and measures.[5]

Meanwhile, a Senate committee of the Second Congress, appointed November 1, 1791, recommended the fixing of a standard for weights and measures and indicated directions for the scientific construction of a standard rod and its divisions. It also recommended the adoption of a decimal system of weights and measures which was practically the same as had been recommended by Jefferson in his report of July 4, 1790, as one of the alternatives. This report came up for discussion at various times during the second session, but no legislation resulted. There was, however, a law enacted, April 2, 1792 (1 Stat. L., 250), establishing a decimal system for the money of the United States.

Other reports of congressional committees, based on Jefferson's report, were made in 1792, 1793, and 1796. There was much discussion of this subject in Congress at this period, and several bills and resolutions were introduced, especially in 1796, but without legislative action.

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[4] *Ibid.*, pp. 38-39.

[5] 4 Cong., 1 sess., ex. docs.

Efforts on the part of scientists, statesmen, and business men were not lacking, however, even in this early period, to bring about legislation for uniform standards of weights and measures. In 1798, as a result of a resolution of the legislature of the State of Rhode Island, a House committee of seven members was appointed to consider " the fixing of an uniform plan of weights and measures," and in 1804 and 1808 other House committees were appointed, following the receipt of resolutions from the legislatures of Pennsylvania and New Jersey.

On December 3, 1816, President Madison in his eighth annual message said, " Congress will call to mind that no adequate provision has yet been made for the uniformity of weights and measures also contemplated by the Constitution. The great utility of a standard fixed in its nature and founded on the easy rule of decimal proportions is sufficiently obvious. It led the Government at an early stage to preparatory steps for introducing it, and a completion of the work will be a just title to the public gratitude." The following day, select committees of the House and Senate respectively, were appointed to consider " so much of the President's message as relates to the uniformity of weights and measures."

The Senate select committee, on March 1, 1817, reported a resolution " That it be referred to the Secretary of State, to prepare and report to the Senate a statement relative to the regulation and standard for weights and measures in the several States, and relative to proceedings in foreign countries for establishing uniformity in weights and measures, together with such propositions relative thereto as may be proper to be adopted in the United States.[6] The resolution was adopted, March 3, 1817.

On January 25, 1819, a committee of the House of Representatives was appointed to inquire into the expediency of fixing the standards of weights and measures. The committee agreed unanimously that the subject should not be left to " uncertain usages, or to the various laws of particular states," and proposed the procuring of " models of the yard, bushel, wine gallon and pound supposed to conform to those in most common use in the United States," which on proving satisfactory to Congress, might be declared to be standards of measures and weights of the United

[6] Annals of Congress, Vol. 30, pp. 197, 202.

States, copies of them to be distributed to the states. It also recommended that models of weights and measures, exactly compared with their several standards, shall be deposited in the different states and with the customs collectors, and submitted a set of resolutions recommended for adoption by the Senate and House of Representatives.[7] These recommendations, however, did not result in legislation.

Early History of Metric System. In the meantime France was devoting much attention to the matter of a uniform standard of weights and measures, and on August 1, 1793, a law for the adoption of a metric system was enacted in that country. By a decree of the Committee of Public Saftey of France, dated December 11, 1793, a weights and measures commission was directed to send to the United States of America a meter in copper and a weight, these being copies of the standards then adopted. The standards were sent to the State Department August 2, 1794, together with a letter by the French Government urging the adoption of the metric system by the United States Government. This letter was transmitted to Congress, January 8, 1795. The nomenclature of the French metric system was established by the law of April 7, 1795.

The metric standard adopted by the French Government at that time was not a standard of the French Academy of Science. While scientific committees of the Academy were occupied with making the measurements of an exact standard, the French government, impatient of delay, adopted a provisional standard based on measurements made in 1740. The measurements which had been begun by the French Academy of Science were subsequently completed by a committee composed of members of the National Institute of France and of deputies from foreign countries. This committee found an error of one-seventh of a line or one-hundredth of a U. S. inch in the provisional meter, and of 14.85 grains of the provisional kilogram. The French Government, therefore, on December 10, 1799, abolished the provisional meter and kilogram ordained by the laws of August 1, 1793, and April 7, 1795, and adopted new standards generally called the Standards of the Archives. These have since been completely replaced, by international agreement, by the International prototype. (See p. 23.)

[7] American State Papers, Misc., Vol. II, p. 538.

Among the deputies from foreign countries who served on the committee of the Institute of France in preparing the metric standard was J. G. Tralles, the deputy from the Helvetic Republic, who had been placed in charge of the construction of the meters. He constructed several iron bars whose lengths were ascertained in the process of constructing the original meter of the French Committee of the Academy of Science and known as the Meter of the Archives. These iron bars were distributed among the members of the committee, Mr. Tralles retaining two, one of which he presented to Ferdinand R. Hassler, who later became the Superintendent of the United States Office of Weights and Measures.

When Hassler came to the United States in 1805 he presented to the American Philosophical Society of Philadelphia the meter which he had received from Mr. Tralles and which has since been known in this country as the "Committee Meter." Later, when Hassler was given charge of the Survey of the Coast, it was placed at his disposal by the Society, and it has remained in the custody of the National Government ever since. He made it the standard of length for his coast surveys, and it remained the standard to which all geodetic base line measurements were referred until 1890. In 1821, Albert Gallatin, then Minister of the United States to France, procured a platinum kilogram and a platinum meter, which he sent to the United States. These had been compared with prototypes in the French archives and certified by Arago, the celebrated physicist. The kilogram was certified as differing less than one milligram from the original.

Report of John Quincy Adams, Secretary of State. The Senate resolution of March 3, 1817, calling for a report from the Secretary of State, was followed on December 14, 1819, by a similar House resolution. In response to these two resolutions, John Quincy Adams, then Secretary of State, made a report on February 22, 1821, which contained one of the most complete and comprehensive statements of the history and status of weights and measures that has ever been prepared.[8] Dr. S. W. Stratton, former Director of the Bureau of Standards, has characterized it as "a classic in weights and measures literature."[9] The report dealt with weights and measures not only in this country, but in foreign countries as well.

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[8] American State Papers, Misc., Vol. II, pp. 656, 701; also 16 Cong., 2 sess., S. doc. 119.

[9] Centennial celebration of the Coast and Geodetic Survey, p. 26.

In this report Adams recommended the fixing of the standard of weights and measures as they existed in the United States at the time, and advised consultation with foreign nations for the ultimate establishment of universal and permanent uniformity. In making this recommendation he said, "To fix the standard of weights and measures of the United States as they now exist, it appears that the act of Congress should embrace the following objects:

1. To declare what are the weights and measures to which the laws of the United States refer as the legal weights and measures of the Union.
2. To procure positive standards of brass, copper, or such other materials as may be deemed advisable, of the yard, bushel, wine and beer gallons, troy and avoirdupois weights; to be deposited in such public office at the seat of the Government as may be thought most suitable.
3. To furnish the executive authorities of every State and Territory with exact duplicates of the national standards deposited at the seat of the Government.
4. To require, under suitable penal sanctions, that the weights and measures used at all customhouses, and land surveys, and post offices, and generally, by all officers under the authority of the U. S., in the execution of their laws, should be conformable to the national standards.
5. To declare it penal to make or to use, with intent to defraud, any other weights and measures than such as shall be conformable to the standards.

The existing weights and measures of all the States of this Union are derived from the exchequer, or from the laws of Great Britain. The one common standard from which they are all deduced is the English foot, divided into twelve inches, and three of which constitute the yard. The positive standard yard is a brass rod of the year 1601, in the British exchequer. [Since replaced.] The unit of measure is the foot of 12 inches. The inch, by the English laws, is divided into three equal parts, called barleycorns; but this division is not used in practice. The practical divisions of the inch are, at option, binary or decimal. . . . Thirty-two cubic feet of spring water, at the temperature of 56 degrees of the thermometer of Fahrenheit, constitute the ton weight of two thousand pounds avoirdupois. The pound avoirdupois consists of sixteen ounces; the ounce of sixteen drachms. . . .

> For the purposes of the law, it will be sufficient to declare that the English foot, being one-third part of the standard yard of 1601 in the exchequer of Great Britain is the standard unit of the measures and weights of the United States; that an inch is a twelfth part of this foot; that 32 cubic feet of spring water, at a temperature of 56 degrees of Fahrenheit's thermometer, constitute the ton weight of 2000 pounds avoirdupois; that the gross hundred of avoirdupois consists of 112 pounds, the half hundred of 56, and the quarter hundred of 28, the eighth of a hundred of 14, and the sixteenth of a hundred of 7 pounds; that the troy pound consists of 5,760 grains, 7,000 of which grains are of equal weight with the avoirdupois pound; that the bushel is a vessel of capacity of 2150.42 cubic inches; the wine gallon a measure of 231, and the ale gallon a measure of 282 cubic inches.
>
> The various modes of division of these measures and weights, the ell measure, and the application of the foot to itinerary, superficial, and solid measure producing the perch, rood, furlong, mile, acre, and cord of wood, may be left to the established usage, or specifically declared as may be judged most expedient. The essential parts of the whole system are the foot measure, spring water, the avoirdupois pound, and the troy grain.
>
> For the purpose of uniformity, it would be desirable to obtain a copy, as exact as the most accomplished art could make it, of the standard yard of 1601, in the exchequer of Great Britain, made of the same material (brass), but divided with all practicable accuracy into three feet and thirty-six inches, and each inch further divided into tenth and hundredth parts. This rod, with the words "standard yard measure of the United States—three feet—thirty-six inches," and the date of the year engraved in one of its sides, should be enclosed in a wooden case, and deposited for safekeeping in one of the offices of the Capitol. From the foot measure of this yard the standard bushel and two gallons should be made. The avoirdupois pound and the troy weight of 256 ounces should be made exactly conformable to the standards of the exchequer.

As to the method of enforcing the use of standards of weights and measures Adams recommended that public officers of the United States Government, such as customs officers, public land surveyors, postmasters, etc., be required to use weights and measures conformable to the standard of the United States, in the performance of their public duties, but he did not favor control over individuals in the use of the standard, such legislation being in his opinion within the province of the individual states.

He also recommended "that in the act for fixing the standard of weights and measures for the United States together with a definition of the foot, its exact proportion to the standard metre of France should be declared," and "that the President of the United States be requested to communicate, through the ministers of the United States in France, Spain and Great Britain, with the Governments of these nations upon the subject of weights and measures, with reference to the principle of uniformity as applicable to them." He concluded his report by saying that "the plan which is thus, in obedience to the injunction of both houses of Congress, submitted to their consideration, consists of two parts, the principles of which may be stated: (1) To fix the standard, with the partial uniformity of which it is susceptible, for the present, excluding all innovation. (2) To consult with foreign nations for the future and ultimate establishment of universal and permanent uniformity."

Further Efforts for Standardization Legislation. A committee of the House of Representatives to whom Adams' report had been referred, offered on March 11, 1822, a set of resolutions for congressional adoption, requesting the President of the United States, with the consent of the British government, "to cause to be traced on a rod of platina, the yard of the year 1601, which is kept in the British exchequer; to cause to be made of platina a pound of the weight in vacuo of the English avoirdupois pound; and that he also cause to be made of whatever material he shall deem best for standards of these measures, a vessel of the same capacity as the standard Winchester bushel, and also a vessel of the same capacity as the standard wine gallon of England."[10]

The proposed resolution further provided: "That the President be requested to cause to be made, for distribution among the States and Territories, and for the purpose of verifying the weights and measures used therein, models of the yard, on which shall be traced its divisions of feet and inches; models of the bushel, half bushel, quarter bushel, or peck, thirty-second part of a bushel or quart; models of the wine gallon, of the wine quart and pint; models of the pound, half pound, quarter pound, of the sixteenth of a pound, or ounce, of the seven-thousandth part of a pound, or grain; models of the pennyweight or twenty-four grains, of the scruple or twenty grains, and of the apothecaries dram or sixty grains; models of the weight of twelve and a half pounds, of twenty-five pounds, of fifty pounds and of one hundred pounds; that these models of weight and measure be formed with the utmost practical exactness from the weights and measures procured under the authority of the foregoing resolution."

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[10] American State Papers, Misc., Vol. II, p. 927.

This recommendation, like preceding ones of a similar character, failed to receive legislative action.

Again on May 16, 1826, a committee on weights and measures of the House of Representatives reported a joint resolution for the employment of a metrologist to make experiments designed to establish a standard of measurement; and although this resolution was introduced, debated and ordered to a third reading, no further action seems to have been taken concerning it.

Adoption of the Troy Pound of the Mint. In 1827 the United States Minister to Great Britain procured a brass troy pound weight copied by Captain Henry Kater of the British Government from the British troy pound of 1758, which became the imperial standard of weight after May 1, 1825. The copy was deposited with the Director of the Mint in September, 1827.

On May 19, 1828 (4 Stat. L., 278), this troy pound weight was adopted by Congress as the standard for coinage. Thus, while Congress ignored the confusion in commercial transactions resulting from the absence of legal standards, it realized the necessity of having a legal standard, at least, for the coinage of money. Section 2 of this act provided: "That for the purpose of securing a due conformity in weight of the coins of the United States the provisions of the ninth section of the act passed the second of April, 1792, entitled 'An act to establish a mint, and regulating the coins of the United States,' the brass troy pound weight procured by the minister of the United States at London in the year 1827, for the use of the Mint at Philadelphia, shall be the standard troy pound of the Mint of the United States, conformably to which the coinage thereof shall be regulated."

An act approved February 12, 1873 (17 Stat. L., 424, 432, amending the laws relating to the Mint, reenacted these provisions concerning the troy pound weight. This troy weight remained the standard for coinage until it was replaced by the standard of the Bureau of Standards in accordance with an act approved March 4, 1911 (36 Stat. L., 1354).

The original Troy pound of the mint was an exact copy of the imperial Troy pound of Great Britain, according to the statement of Captain Kater, who made the comparison between the two standards.

The act of March 4, 1911, provides that Sections 3548 and 3549 of the Revised Statutes be amended to read as follows:

> SEC. 3548. For the purpose of securing a due conformity in weight of the coins of the United States to the provisions of the laws relating to coinage, the standard troy pound of the Bureau of Standards of the United States shall be the standard troy pound of the Mint of the United States, conformably to which the coinage thereof shall be regulated.
>
> SEC. 3549. It shall be the duty of the Director of the Mint to procure for each mint and assay office, to be kept safely thereat, a series of standard weights corresponding to the standard troy pound of the Bureau of Standards of the United States, consisting of a one pound weight and the requisite subdivisions and multiples thereof, from the hundredth part of a grain to twenty-five pounds. The troy weight ordinarily employed in the transactions of such mints and assay offices shall be regulated according to the above standards at least once in every year under the inspection of the superintendent and assayer; and the accuracy of those used at the Mint at Philadelphia shall be tested annually, in the presence of the assay commissioners at the time of the annual examination and test of coins.

The change from the troy pound of the mint to the standard of the Bureau of Standards did not involve any change in the actual value of the mint weights, but merely substituted the platinum-iridium kilogram for the old brass mint pound as the fundamental standard. As a result, there is now but a single standard of mass for all purposes in the United States.

Executive Action Concerning Standard Weights and Measures. The use of weights and measures by custom officers in the collection of duties on imports became necessary upon the enactment of the first tariff act, July 4, 1789 (1 Stat. L., 24), which imposed specific as well as ad valorem duties on imports.

Later acts defined the duties of customs officers with regard to gauging, weighing, or otherwise measuring imported commodities. There was no provision in the earlier tariff or internal revenue acts, however, defining the measures to be used or insuring such accuracy and uniformity of measurement as were indispensable for proper compliance with the Constitutional provision that "all duties, imposts and excises shall be uniform throughout the United States." Likewise, the act of July 20, 1789 (1 Stat. L., 27), imposing a tonnage tax on vessels, did not define or make any provision for the definition or standardization of the ton.

It was, therefore, left to the discretion of the executive authorities to adopt such standards of weight and other measurement as seemed most expedient, and to take such steps for securing uniformity and accuracy as the means at their command permitted.

Inaccuracy of Standards at Custom Houses. The first legislative provision of Congress designed to secure uniformity and accuracy of weights and measures was contained in the act of March 2, 1799 (1 Stat. L., 643), "To regulate the collection of duties on imports and tonnage." This required semi-annual comparisons to be made of all the weights and measures used in Custom Houses. The act provided that:

> The surveyor shall . . . from time to time, and particularly the first Mondays in January and July in each year, examine and try the weights, measures and other instruments, used in ascertaining the duties on imports, with standards to be provided by each collector at the public expense for that purpose; and where disagreements or errors are discovered, he shall report the same to the collector, and obey and execute such directions as he may receive for correcting thereof, agreeably to the standards aforesaid.

There is no record to show that this provision of law was enforced until about thirty-five years later, the reason for the failure probably being that no standards had been adopted either by Congress or by the Treasury Department.

The same act (1 Stat. L., 675) prescribed the method of ascertaining the tonnage of vessels, but did not define the ton.

Until the time John Quincy Adams began the preparation of his report to Congress, early in 1820, no serious effort had been made to secure accuracy and uniformity of measurement in the collection of duties and other revenues, or to ascertain the status of such measurements at the various customhouses. Adams in the preparation of his report called for information on this subject, with the result that the Register of the Treasury addressed letters to the collectors of customs throughout the United States, directing them to report concerning the nature of the weights and measures in use in the custom houses. The returns from forty-nine collectors were tabulated and presented in the report. This is believed to be the first general collection of facts made in the United States concerning weights and measures used in the computation of duties.

According to a House select committee report of February 27, 1835,[11] "It exhibited the extraordinary circumstance that, with perhaps a single exception there were not two custom houses in the United States at which the capacity of the bushel and half bushel in use was the same. . . . The table also showed that the grains troy in the pound avoirdupois, instead of being uniformly 7000 varied in different custom houses from 6938 to 7032."

Services of Ferdinand R. Hassler. While the futile efforts were being made to secure legislation for the adoption of accurate, uniform standards of weights and measures, the executive branch of the government, particularly the Treasury Department, was taking definite steps to secure and establish uniform accurate standards for use in its various activities. In the history of the metrological work of the government, as in that of the Survey of the Coast, the name of one man stands out preeminently, namely Ferdinand R. Hassler, a Swiss engineer, who had emigrated to this country in 1805.

When the act of February 10, 1807 (2 Stat. L., 413), was approved authorizing the President to cause a survey to be made of the coasts of the United States, and when subsequently, plans for this work were solicited from scientists by the President, Hassler, then an instructor of mathematics at the Military Academy at West Point, presented the plans which were accepted by the government, and received an appointment as the first superintendent of the Survey of the Coast.[12]

As the instruments necessary for this work were not available in the United States, Hassler, in 1811, proceeded to Europe to procure them. Being detained there on account of the war, he did not return until 1815. While engaged in obtaining the instruments for the coast survey, Hassler, being one of the leading metrologists of his time, devoted considerable of his attention to securing standards of weights and measures for his government.

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[11] 11 Cong. 2 sess., 1835, Register of Debates, Appendix, p. 328.

[12] See Institute for Government Research, The Coast and Geodetic Survey, pp. 2-6.

On account of congressional interruption of the work of the Coast Survey, first by failure to appropriate the necessary funds for its prosecution (1816), and later by taking the survey work, for a time, out of civilian hands (1818-1832), the metrological work of the Treasury Department and the survey of the coast were practically suspended for many years. With the reorganization of the Coast Survey and the return of Hassler as its superintendent in 1832, the real work of providing and duplicating accurate standards of weights and measures was begun. The year 1832, therefore, may be regarded as marking the beginning of the activities of a separate office, which later grew to dimensions calling for the establishment of the Bureau of Standards. The Office of Weights and Measures, under various names, remained under the direction of the Superintendent of the Coast Survey, which it served as well as the Customs Service and other branches of the government and the public. In 1834 and 1835 the Coast Survey was a second time placed under the Navy Department, which resulted in another interruption of this work.

On May 29, 1830, a Senate resolution was adopted directing the Secretary of the Treasury to have an examination made of the standards in use in the principal custom houses, and to report at the next session of Congress.

The duty of making this examination devolved upon Hassler, who appeared to be the most capable man available for this work. He collected standards from the different governmental departments, and from other domestic and foreign sources, and the weights and measures from the different custom houses, all of which were compared with minute accuracy, and the results were recorded and incorporated in two reports rendered January 27, and June 29, 1832.[13] Hassler reported that he had found large discrepancies among the weights and measures in use at the custom houses: "Hardly any custom houses had actual standards. All equally refer, for weights and measures of any kind to the city sealers of the place or those appointed by the respective states."

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[13] 22 Cong. 1 sess., H. doc. 299.

In letters to the Senate from the Secretary of the Treasury, dated March 3, 1831, and June 20, 1832, the latter transmitting Hassler's report of January 27, attention was called to these discrepancies in the weights and measures and the recommendation was made that standards be prepared by the Treasury Department and furnished to the custom houses.

Adoption of Standards by the Treasury Department. On February 27, 1835, a select committee of the House of Representatives made an elaborate report calling attention to the discrepancies disclosed in Hassler's report and to the power of Congress under the Constitution with regard to standard weights and measures and the requirement concerning uniformity of duties and excises, and reviewing the efforts that had been made in the past to secure uniform standards. The report concluded with the submission of the following resolution:

> That it is highly expedient that the Treasury Department should complete, with as little delay as practicable, the fabrication of standards of weights and measures, for the supply of the different custom houses of the United States, upon the principles set forth in the reports of the Secretary of the Treasury to the Senate, on the 3d of March, 1831, and 20th of June, 1832.[14]

There is no record, however, of the adoption of this proposed resolution by Congress.

Without awaiting congressional action, the Secretary of the Treasury directed Hassler to secure apparatus and to establish a shop at the United States Arsenal at Washington, wherein copies of standards adopted by the Treasury Department could be made for distribution to the various customhouses. He was provided with the necessary funds, and the actual work was begun in 1835. A report dated November 28, 1835,[15] shows the preliminary measures taken for the execution of this work.

The actual standards adopted for this purpose by the Treasury Department in 1832 upon the recommendation of Hassler were:

Standard of length: The standard of length was a brass bar containing a scale 82 inches in length, prepared for the Survey of the Coast of the United States, by Troughton of London in 1813 and deposited in the Office of Weights and Measures. The temperature at which this scale was a standard was 62° Fahrenheit, and the yard measure was between the 27th and 63d inches of the scale. This bar had been brought to the United States by Hassler.

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[14] Register of Debates, 1835, pp. 328-33, and 23 Cong. 2 sess., H. R. Rept. 132.

[15] 28 Cong. 2 sess., S. doc. 149.

Units of Capacity: The gallon for liquid measure was a vessel containing 58,372.2 grains (8.3389 pounds avoirdupois) of the standard pound of distilled water, at the temperature of maximum density of water, the vessel being weighed in air in which the barometer was 30 inches at 62° Fahrenheit. This was the wine gallon of 231 cubic inches introduced in England in 1707, but abolished by that country in 1824.

The bushel was a measure containing 543,391.89 standard grains (77.6274 pounds avoirdupois) of distilled water, at the temperature of maximum density of water, and barometer 30 inches at 62° Fahrenheit. This standard bushel of 2150.42 cubic inches was the Winchester bushel which, like the wine gallon, had been abolished in England in 1824.

Standard of Weight: The standard of weight was the troy pound of the United States Mint, a troy pound, copied by Captain Kater, in 1827 from the imperial troy pound, for our Mint, and preserved in that establishment.

The avoirdupois pound was derived from the troy pound. The ratio of the avoirdupois pound of the United States to the troy pound was defined to be 7000 to 5760.

While the standards of length and of weight corresponded with those then adopted by England, the measures of capacity were somewhat smaller.

Supply of Standards to States. As a result of recommendations made by the House Committee on Commerce on January 30, 1836, and March 21, 1836, Congress adopted the following resolution on June 14, 1836 (5 Stat. L., 133):

> That the Secretary of the Treasury be, and he hereby is, directed to cause a complete set of all the weights and measures adopted as standards, and now either made or in progress of manufacture for the use of the several custom-houses, and for other purposes, to be delivered to the Governor of each State in the Union, or such person as he may appoint, for the use of the States, respec-

tively, to the end that a uniform standard of weights and measures may be established throughout the United States.

While this resolution did not establish the standards adopted by the Treasury Department, the effect of it was practically the same, for in almost every case the legislatures of the different states adopted them as standards soon after their receipt.

An act of July 7, 1838 (5 Stat. L., 267), contained a provision "that the Secretary of the Treasury cause to be made under the superintendence of Hassler, one standard balance for each state, and when completed, that he cause them to be delivered to the respective Governors for the use of the respective states."

The work of preparing these standards of weights and measures and balances was a very slow and tedious one, and although Hassler held office until his death, November, 1843, he did not complete the task.

The weights for the states were reported finished and ready for delivery by 1838, and those for the custom houses were finished and delivered the following year. At the time of Hassler's death, there had been finished in addition, nearly half of the capacity measures and about one-third of the measures of length required to supply the states and custom houses, and the work on the balances for the states had been begun.

On August 14, 1856, a resolution was adopted by the Senate requesting the Secretary of the Treasury "to communicate to the Senate in December next, a report from the superintendent of weights and measures showing the number and kind of standards and of balances made and distributed to the states and custom-houses and the legislation of the different states in relation to the standard weights and measures."

In response to this resolution, the Secretary of the Treasury on December 31, 1856, transmitted an elaborate report by Alexander D. Bache, then Superintendent of the Office of Weights and Measures.

At the time of Bache's report full sets of standard weights and measures and balances for the states had been completed, and nearly all had been delivered. The custom houses had been furnished with one hundred and four sets of weights, nineteen standard gallons, twenty-four sets of parts of the gallon, twenty-two standard yards, and eleven standard bushels.

In compliance with a Senate resolution of December 14, 1858, the Secretary of the Treasury submitted another detailed report prepared by the Superintendent of Weights and Measures in 1857, showing the weights and measures furnished the several states and custom houses, and their cost.

A deficiency appropriation act of March 3, 1875 (18 Stat. L., 409), made a special appropriation " for the construction and verification of standard weights and measures for custom houses of the United States and for the several states."

Supply of Standards to Foreign Governments. The burning of the British Houses of Parliament in October, 1834, resulted in the destruction of the British imperial yard and troy pound made in 1758, of which the Troughton scale and the mint pound were supposed to be exact copies. Under date of June 1, 1843, the Secretary of the Treasury informed the Secretary of State that " by direction of the President, in conformity with a resolution which actually passed both Houses of Congress at the last session, although not announced by the Senate to the House,"[16] there had been forwarded to the Collector of New York for presentation to the government of Great Britain, through the American Minister in London, a set of standard weights and measures, and a balance, with a memoir explaining the principles upon which they ware formed and directions for their use. They were delivered at the office of the British Treasury, July 22, 1843.

By a joint resolution approved June 30, 1848 (9 Stat. L., 336), the Secretary of State was directed to furnish the French government with a complete series of standard weights and measures of the United States. This direction was complied with in November, 1850.

Balances and standards were also supplied about this time (1851-1853) to Siam and Japan by Commodore Perry, under the authority of the Treasury Department.

Adoption of New British Standards by the U. S. Treasury Department. After the destruction of the standards of Great

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[16] Weights, measures and balances, 28 Cong. 1 sess., H. doc. 94, p. 7.

Britain, the British government took steps to replace them, and when this work was completed in 1855, one copy of the avoirdupois pound and two copies of the yard were presented to the United States, the copies being received in Washington the following year.

The new imperial yard standards were found, on comparison, to be 0.00087 inch shorter than the Troughton scale which had been accepted by the Treasury Department as a standard. The new yards, and especially the one known as "Bronze No. 11," were regarded as far superior to the Troughton scale as standards of length, and were consequently accepted by the Office of Weights and Measures as the standards of the United States.

The avoirdupois pound received from England in 1856 was found, on comparison, to agree satisfactorily with the United States standard avoirdupois pound derived from the mint pound, and did not therefore disturb the position of the troy pound of the mint or the avoirdupois pound derived from it.

In 1879 and 1880 two elaborate reports were issued by the Office of Weights and Measures on the "Relation of the lawful standards of measure of the United States to those of Great Britain and France,"[17] and on a "Comparison of American and British standard yards."[18]

International Bureau of Weights and Measures. The most important event in the entire history of weights and measures was the creation in 1875, more than fifty years after its recommendation by John Quincy Adams, of an international organization for the establishment of a world-wide uniformity in standards.

Although the French metric system had been adopted in many countries, the copies of the legal French standards in use differed to such an extent that difficulties arose in the work of geodetic surveying. The relation of the several copies to their prototypes in France was not known with a degree of precision in keeping with the requirements of science. Furthermore, the standards of the Archives of France, made in the eighteenth century, were not constructed with the degree of perfection attainable in 1870.

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[17] Coast and Geodetic Survey, Annual Report, 1878.

[18] Ibid., 1876, Appendix 23; Ibid., 1877, Appendix 12.

The French government therefore invited other countries to send delegates to a conference to be held in Paris on August 8, 1870, to consider the advisability of constructing new metric standards. Fifteen countries, including the United States, participated, but, on account of the outbreak of the Franco-Prussian war, the conference was abandoned.

At a second conference in 1872, at which thirty countries were represented, it was decided that new meters and new kilograms should be constructed to conform to the original standards of the Archives of France, and a permanent committee was appointed to carry out this decision. At the request of this permanent committee, the French government called a diplomatic conference, which was held in March, 1875, at which nineteen countries were represented. On May 20, 1875, seventeen of the nineteen countries signed a convention for the establishment and maintenance of a permanent International Bureau of Weights and Measures.[19]

This convention provided for the establishment of a " scientific and permanent international bureau of weights and measures to be located at Paris, France." The bureau was placed under the direction and supervision of an international committee of weights and measures, which in turn was placed under the control of a general conference for weights and measures composed of the delegates of all the contracting parties. A director and a force of assistants and other employees constituted the bureau personnel.

The International Bureau, according to the regulations which accompany the convention, is required to be in a building possessing all the necessary safeguards of quiet and stability, and to be specially devoted to this purpose. As subsequently constructed, the laboratory building contains besides a vault for the safe-keeping of the prototypes, rooms for mounting the comparators and balances. Other buildings contain a library, a room for the archives, work rooms for the employees, and apartments for the director and several other employees. The Bureau is located on neutral territory at Sèvres, near the city of Paris.

The functions of the Bureau as defined by the convention are:

First: All comparisons and verifications of the new prototypes of the meter and kilogram.

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[19] 20 Stat. L., 709, see also 43 Stat., Pt. 2, Treaties, p. 66.

Second: The custody of the international prototypes.

Third: The periodical comparison of the national standards with the international prototypes and with their test copies, as well as comparisons of the standard thermometer.

Fourth: The comparison of the prototypes with the fundamental standards of non-metrical weights and measures used in the different countries and for scientific purposes.

Fifth: The sealing and comparison of geodesic measuring-bars.

Sixth: The comparison of standards and scales of precision, the verification of which may be requested by governments or by scientific societies, or even by constructors or men of science."

The international prototypes of the meter and of the kilogram and the test copies of the same are deposited in the Bureau and access to them is only allowed to the international committee.

The expense of constructing, outfitting, and maintaining the International Bureau and the expenses of the committee are defrayed by contributions from the contracting states, the amount of which is computed in proportion to the actual population of each.

The convention was signed by the representatives of the United States on May 20, 1875. Ratification was advised by the Senate May 15, 1878, and it was accordingly ratified by the President May 28, 1878. Ratifications were exchanged at Paris, on August 2, 1878, and the convention was proclaimed September 27, 1878 (20 Stat. L., 709). This convention was amended by a convention signed at Sèvres October 6, 1921, the ratification of which was advised by the Senate January 5, 1923, ratified by the President September 19, 1923, and proclaimed October 27, 1923.

The first appropriation to meet the treaty obligations arising from the convention was made by an act of June 20, 1878 (20 Stat. L., 217), the original amount being $13,124 to cover the stipulated contribution of the United States to June 30, 1879. Since then appropriations have been regularly made for the expense of participation in the maintenance of the International Bureau. Originally these payments were made through the Treasury Department, but since 1881[20] the Department of State has been making these disbursements. On March 3, 1881 (21 Stat. L., 441), an appropriation of $600 was made " for expenses of the attendance of the American member of the International Committee on Weights and Measures at the sexennial general conference provided for in the convention signed May 20, 1875."

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[20] Act of March 3, 1881 (21 Stat. L., 455).

A special committee of the international organization was entrusted with the construction of the meters and kilograms. After making three preliminary meters and three preliminary kilograms, thirty meters and forty kilograms were constructed and compared with the meter and kilogram of the Archives. This work was completed in 1889. At a general conference held in that year at Paris the work of this committee was approved. The meter and the kilogram which were found by long series of observations to agree most closely with those of the Archives were declared to be the International Meter and the International Kilogram respectively. From that date the Standards of the Archives ceased to be reference standards. They are now of historical interest only.

The other standards were distributed by lot to the contributing countries, those obtained by the United States being designated as meters Nos. 21 and 27 and kilograms Nos. 4 and 20. Later on, two meter bars made of the alloy of 1874 (platinum iridium) were obtained by the United States, and are known as "Meters Nos. 4 and 12."

The copies of the international standards allotted to the United States were deposited in the Office of Weights and Measures in Washington in 1890, but were transferred to the Bureau of Standards upon its creation in 1901.

In 1892 observations were made for determining the relation between British Yard Bronze No. 11 and Low Moor Iron No. 57 on the one hand, and National Prototype Meter No. 21 on the other. The result of the comparison did not change the legal relation, established for commercial purposes in the United States, of the yard and meter.

Legalization of the Metric System. The interest of Congress in an international standard of weights and measures appears to have been revived in 1866, when on May 17, the chairman of the House Committee on Coinage, Weights and Measures presented two bills and one resolution relating to the adoption of the metric system, all of which measures were subsequently enacted.

The first of the bills (H. R. 596) was enacted July 28, 1866 (14 Stat. L., 339).[21] It made it lawful to employ the weights and measures of the metric system throughout the United States and provided that "no contract or dealing, or pleading in any court be deemed invalid or liable to objection because the weights and measures expressed or referred to therein are weights or measures of the metric system." The act provided a table of equivalents between metric denominations and the denominations in use in the United States, and since that time the relation, 1 meter = 39.37 inches, has been regarded as exact, and all standards of length in the United States have been based on this relation. There was no provision making the use of the metric system in any way compulsory.

It may be said, however, that the legal status of the metric system, became by the act of July 28, 1866, superior in some respects, to the customary system of weights and measures, because Congress thereby legalized the metric system as a whole and specifically stated the relation of the various units to one another, which it had never done with regard to the system of weights and measures in common use in the United States. Congress has never adopted material standards for the customary system of weights and measures, but has left this matter to the direction of the Treasury Department.[22] It may be mentioned, however, in this connection, that while the metric system never came into general use in commercial transactions in the United States, it is extensively used among technical and scientific men, and it is in general use and is the legalized system of weights and measures in the Philippine Islands, Porto Rico, and Guam.

A bill introduced May 17, 1866 (H. R. 597), which became a law July 27 (14 Stat. L., 301), authorized the distribution to certain post offices of postal balances denominated in grams of the metric system. This act was intended to give legal sanction to a policy already adopted by the Post Office Department in connection with its foreign transactions.

While these bills for the legalization of the metric system were pending in Congress, a House resolution was adopted, July 16,

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[21] See page 245.

[22] Fischer, Laws concerning weights and measures, 1912, p. viii.

1866, calling upon the Secretary of State to communicate to the House "any information he has received from the United States Commissioner General to the Paris Exposition in relation to international movements for a reform of the system of coinage, weights and measures." The information was furnished to the House the following day.

An act of June 8, 1872 (17 Stat. L., 301), required the Postmaster General to "furnish to the post offices exchanging mails with foreign countries, and to such other offices as he may deem expedient, postal balances denominated in grams of the metric system, fifteen grams of which shall be an equivalent, for postal purposes, of one-half ounce avoirdupois."

On November 6, 1877, a resolution was adopted by the House of Representatives calling upon the heads of the executive departments for their opinions regarding the obligatory use of the metric system of weights and measures in all governmental transactions, and in transactions between individuals. The opinions expressed by the heads of departments and of bureaus, in response, with very few exceptions were adverse to the obligatory use of the metric system both in governmental transactions and in transactions between individuals.

In 1884 an iron standard yard (No. 57) and the standard Arago platinum kilogram in the custody of the Office of Weights and Measures of the Treasury Department were taken to England and to France, respectively, for comparison with the original standards, and were brought back the same year.

In his annual report for 1890, the Superintendent of the Coast and Geodetic Survey recommended that Congress be requested to take steps to insure the introduction of the metric system in the Customs Service, and the Secretary of the Treasury, the same year, recommended that the metric system should be made obligatory in transactions at United States custom houses. These recommendations were made in view of the fact that the metric system had been adopted by most of the civilized countries, and that the International American Conference had recommended its adoption in the three Americas. No legislation of this character was enacted, however.

In 1894 an order was approved by the Secretary of War requiring the use of the metric system in all requisitions, invoices, receipts, and returns pertaining to medical supplies in the War Department. The same order advised the immediate writing of official prescriptions in accordance with the metric system, and made it compulsory after January 1, 1895.

On November 21, 1902, a regulation for the government of the Public Health and Marine Hospital Service was promulgated by the President requiring all officers of that service to make use of the metric system for all official medical and pharmacal purposes.

Adoption of the International Meter and Kilogram as the Fundamental Standards. Until the receipt of the copies of the international standards by the United States the British imperial yard and pound had been recognized by the Treasury Department as the standards of the United States. On April 5, 1893, the Superintendent of Weights and Measures, with the approval of the Secretary of the Treasury, adopted the international meter and kilogram as the fundamental standards of length and mass in the United States. From these fundamental standards the customary units—the yard and the pound—are derived by the relations: one yard is $\frac{3600}{3937}$ meter, and one pound avoirdupois is 0.453592427 kilogram. The formal announcement of this change in the fundamental standards was made in Bulletin 26 of the Coast and Geodetic Survey issued in that month. Intercomparisons of standards both before and after that date have shown that practically no change was made in any of the units involved.

Supply of Metric Standards to States and Other Institutions. A joint resolution introduced May 17, and adopted July 27, 1866 (14 Stat. L., 369), authorized the Secretary of the Treasury to furnish to each state one set of the standard weights and measures of the metric system. The selection of the standards was left to the Secretary of the Treasury.

In making these sets of standards for the states, the Office of Weights and Measures adopted as its standards to work from, the "committee meter" obtained by Hassler from Tralle[23] as the standard for length, and the platinum kilogram obtained by Gallatin in 1821[24] as the standard of weight. The unit of capacity adopted for this purpose was the volume of the mass of one kilogram of pure water at the temperature of maximum density.

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[23] See page 7.
[24] See page 7.

By the end of the year 1880 practically all the states had been supplied with sets of metric weights and measures.

In addition to requiring the Office of Weights and Measures to furnish standards of weights and measures to custom houses and to the states and territories, Congress in 1881 directed that they be also supplied to agricultural colleges. By a joint resolution approved March 3, 1881, it was provided that a complete set of all the weights and measures adopted as standards should be delivered by the Secretary of the Treasury to the governor of each state for the use of its agricultural colleges which have received United States land grants, and a set of the same to the Smithsonian Institution.

In 1888 and 1889 the Office of Weights and Measures prepared a report on the construction and distribution of standards of weights and measures.

The legislative, executive, and judicial appropriation act of July 11, 1890 (26 Stat. L., 242), provided "that hereafter such necessary repairs and adjustments shall be made to the standards furnished to the several States and Territories as may be requested by the governors thereof, and also to standard weights and measures that have been, or may hereafter be, supplied to United States custom houses and other offices of the United States, under act of Congress, when requested by the Secretary of the Treasury." Other paragraphs provide "for the construction of standard gallons and their subdivisions for the use of the states and territories that have not received the same," and "for purchase of a balance of precision and its mounting."

The sundry civil appropriation act of August 18, 1894 (28 Stat. L., 383), authorizes and directs the Secretary of the Treasury to furnish standard weights and measures to the states, territories and institutions previously supplied, to replace standards which have been lost, a charge being made equal to the actual cost of furnishing such standards.

Early Provisions Concerning Other Standards and Tests. While Congress has not enacted any general legislation establishing fixed standards for the customary weights and measures, but has left this matter to the executive branch of the government as far as their official use is concerned, it has found it necessary almost from the beginning to define, especially in tariff and other revenue acts, certain units to be used in the measurement of specified commodities, and to make provision for instruments to be used for such work. These legal provisions were sometimes carried out by or with the coöperation of the Office of Standard Weights and Measures of the Treasury Department and sometimes entirely by other agencies.

Standard Meters for Alcoholic Liquors. The tariff act of January 12, 1825 (4 Stat. L., 79), authorized the Secretary of the Treasury under the direction of the President "to adopt and substitute such hydrometer as he may deem best calculated to promote the public interest . . . for the purpose of ascertaining the proof of liquors; and that after such adoption and substitution the duties imposed by law upon distilled spirits shall be levied, collected and paid, according to the proof ascertained by any hydrometer so substituted and adopted." This law was enacted to secure accuracy in measurement and consequent uniformity in taxation, but no executive action seems to have been taken concerning its enforcement until nearly twenty years later.

On March 13, 1844, the Superintendent of Weights and Measures was requested by the Secretary of the Treasury to undertake experiments for the comparison of hydrometers in reference to their use in the collection of the revenue, in virtue of authority given by the act of January 12, 1825. Reports made in compliance with this request on February 17, 1845, and February 27, 1847, disclosed great irregularities in proving consequent on the use of hydrometers which did not agree in the indications. As a result improved hydrometers (Tralles) were distributed from 1850 to 1856, together with a manual for their use, to the principal custom houses.

The internal revenue acts of June 30, 1864 (13 Stat. L., 243), and March 2, 1867 (14 Stat. L., 481), have specific provisions concerning the adoption and use of hydrometers for ascertaining the proof of spirits.

The internal revenue acts of March 3, 1865 (13 Stat. L., 472), July 20, 1868 (15 Stat. L., 125), July 14, 1870 (16 Stat. L., 263), and March 1, 1879 (20 Stat. L., 354), make provisions concerning the gauging of alcoholic liquors, such as the definition of the term "proof gallon," and the authorization of the Secretary of the Treasury and the Commissioner of Internal Revenue to prescribe weighing and gauging instruments to be used in the measurement of spirits for revenue purposes.

A joint resolution of February 3, 1868 (15 Stat. L., 246), provided for the appointment, by the Secretary of the Treasury, of a commission of five persons to examine and report upon meters for distilled spirits. The commission was directed to work in coöperation with an existing commission of the National Academy of Sciences.[25]

An act of June 6, 1872 (17 Stat. L., 244), specifies the number of pounds of grain which should constitute a bushel, when used in distilleries.

The internal revenue act of July 13, 1866 (14 Stat. L., 164), specifies the number of gallons to a barrel, and the act of March 1, 1879 (20 Stat. L., 351), defines the gallon when used in the measurement of certain fermented liquors.

Standard Gauge for Bolts, Nuts, and Screw Threads. In May, 1868, a report[26] was submitted by a board of naval engineers to the Chief of the Bureau of Steam Engineering of the Navy Department recommending the adoption of a standard gauge for bolts, nuts, and screw threads for the Navy. This report was forwarded to the Secretary of the Navy on May 15, with the recommendation that the board's determinations be accepted as the Navy standard, and that directions be issued to the various Navy Yards to govern their practice accordingly. This was done by the Secretary the following day.

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[25] The National Academy of Sciences, which among other duties, was formerly entrusted with some of the functions now performed by the Bureau of Standards and still coöperates with it, was incorporated by the act of March 3, 1863 (12 Stat. L., 806). One of the duties imposed upon the Academy by the act, requires it "whenever called upon by any department of the Government" to "investigate, examine, experiment, and report upon any subject of science or art, the actual expense of such investigations, examinations, experiments, and reports, to be paid from appropriations which may be made for the purpose."

[26] Bureau of Engineering. Report of the board to recommend a standard gauge for bolts, nuts, and screw threads for the United States Navy. May, 1868.

Tests of Iron and Steel. On February 1, 1855, the Secretary of the Treasury addressed a letter to the chairman of the Senate Finance Committee requesting an appropriation of $3500 to meet the expenses of a complete series of experiments to test the strength of wrought-iron beams and girders required in the erection of certain public buildings,[27] and on February 21, 1857, the Committee on Manufactures made a report, in response to a Senate resolution of July 22, 1856, on the extent to which iron may be substituted for wood, stone, and brick in public buildings in the United States.[28]

An Army appropriation act of March 3, 1873 (17 Stat. L., 547), made provision: "For improved machinery and instruments for testing American iron and steel." Other appropriation acts for the testing of iron and steel were approved March 3, 1875 (18 Stat. L., 399), and July 31, 1876 (19 Stat. L., 119), the former appropriating $50,000 for this purpose and the latter continuing the appropriation. These tests were directed to be made by a board consisting of army and navy officers and civilian experts. While the tests were not made by the Office of Standard Weights and Measures, they constituted an activity similar to those which later became regular functions of the Bureau of Standards.

A sundry civil appropriation act of June 20, 1878 (20 Stat. L., 223), authorized the Secretary of War "to cause the machine built for testing iron and steel to be set up and applied to the testing of iron and steel for all persons who may desire to use it, upon the payment of a suitable fee for each test." This machine was set up at the Watertown, Massachusetts, Arsenal and annual appropriations have since been made for its preservation, care, use, and operation. An act of May 27, 1908 (35 Stat. L., 354), provided for the transfer of the testing machine at Watertown Arsenal to the Department of Commerce and Labor, but this provision was repealed by the act of March 4, 1909 (35 Stat. L., 905), and this work has remained under the War Department to the present time.

Naval appropriation acts of February 14, 1879 (20 Stat. L., 289), and August 5, 1882 (22 Stat. L., 293), made appropriation for the purchase, by the Bureau of Steam Engineering, of a "testing machine for making tests of plate iron."

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[27] 33 Cong. 2 sess., S. ex. doc. 54.

[28] 34 Cong. 3 sess., S. rep. 408.

Electrical Standards. On July 7, 1884 (23 Stat. L., 194), a sundry civil appropriation act was approved, having a provision "That the President of the United States be, and is hereby, authorized to appoint a scientific commission which may, in the name of the United States Government, conduct a national conference of electricians in Philadelphia in the autumn of 1884; that said commission may invite scientific men, native and foreign, to participate in the conference, and may, in general, determine the scope and character of its work." An appropriation of $7500 was made to meet the expenses of the commission in conducting the conference.

When the conference met, it recommended the establishment of "a bureau charged with the duty of examining and verifying instruments for electrical and other physical measurements" and appointed a "Committee on Bureau of Standards" to represent the conference before Congress. No legislation followed this action, however.

In 1893 an international electrical congress was held in Chicago, at which certain units of electrical measure were adopted. In December, 1893, the Superintendent of the Coast and Geodetic Survey issued a bulletin announcing the formal adoption by the Office of Standard Weights and Measures of these names and values of units of electrical measure.

These definitions of electrical units were enacted into law July 12, 1894 (28 Stat. L., 101).[29] According to this law, the unit of resistance was designated the ohm; unit of current, the ampere; unit of electromotive force, the volt; unit of quantity, the colomb; unit of capacity, the farad; unit of work, the joule; unit of power, the watt; and unit of induction, the henry. The act defined the value of each of these units. The National Academy of Sciences was charged with the duty of prescribing and publishing "such specifications of details as shall be necessary for the practical application of definitions of the ampere and volt hereinbefore given, and such specifications shall be the standard specifications herein mentioned." Appropriation acts of January 12, 1895 (28 Stat. L., 616), and February 2, 1896 (29 Stat. L., 20), made provision for the preparation and publication of these details by the National

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[29] See page 247.

Academy of Sciences and for the reimbursement to that organization of expenses incurred on account of this work.

Subsequent investigations have shown the necessity for slight changes in some of the units and a consequent revision of the law.

In 1895 preliminary steps were taken by the Office of Standard Weights and Measures for making and testing electrical standards in accord with the specifications adopted by the National Academy of Sciences under date of February 20, 1895. This work continued to occupy part of the attention of the Office of Standard Weights and Measures until its transformation into the Bureau of Standards, which then continued it.

Standard Gauge for Sheet and Plate Iron and Steel. On March 3, 1893 (27 Stat. L., 746), an act was approved establishing a standard gauge for sheet and plate iron and steel, giving in tabular form, the number of gauge, thickness, and weight, and directing that "the same and no other shall be used in determining duties and taxes levied by the United States of America on sheet and plate iron and steel." It required the Secretary of the Treasury to prepare suitable standards in accordance with its requirements.

Other Provisions. The mode of measurement of the tonnage of vessels has been dealt with in a number of legislative acts: namely, those of September 1, 1789 (1 Stat. L., 55), August 4, 1790 (1 Stat. L., 169), March 2, 1799 (1 Stat. L., 675), May 6, 1864 (13 Stat. L., 69), and February 28, 1865 (13 Stat. L., 444).

An act of April 2, 1792 (1 Stat. L., 250), prescribes the present system of money as expressed in "dollars or units, dismes or tenths, cents or hundredths, and milles or thousands." Other coinage laws have defined the weight of gold, silver, and other coins.

An act of May 18, 1796 (1 Stat. L., 466), prescribing rules for survey of public lands has a provision that "all lines shall be . . . measured with chains, containing two perches of sixteen feet and one-half each, subdivided into twenty-five equal links, and the chain shall be adjusted to a standard to be kept for that purpose."

At various times from 1824 to 1835 resolutions were passed by the Senate and by the House of Representatives,[30] calling upon the Secretary of the Navy to report upon the relative advantages of domestic and imported hemp for canvas, cables, and cordage used in the equipment of the Navy, and on the expediency and advantage of substituting cotton for hemp and flax for the canvas and clothing of the Navy. Each of these resolutions resulted in the submission, by the Secretary of the Navy, of reports prepared by the Navy Commissioners. The Secretary of the Navy, also in his annual report dated January 31, 1829, mentioned experiments made in his department concerning these matters.

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[30] Senate resolutions of January 22, 1824; May 17, 1824, and House resolutions of March 2, 1827, January 31, 1829, and February 2, 1835.

An act of June 30, 1834 (4 Stat. L., 728), authorized the Secretary of the Navy to employ persons to examine and test a steam engine devised by Benjamin Phillips of Philadelphia and directed him to report the results to Congress. Another act of June 28, 1838 (5 Stat. L., 252), authorized the President to appoint a board of three persons "to test the usefulness of inventions to improve and render safe the boilers of steam engines against explosions."

Acts of August 30, 1842 (5 Stat. L., 567), and March 21, 1861 (12 Stat. L., 196), defined the weight of the ton when used in the collection of import duties.

An act of July 18, 1866 (14 Stat. L., 187), required that for purposes of estimating the duties in importations of grain and peas the bushel should be ascertained by weight, and specified the number of pounds which should constitute a bushel.

An act of July 11, 1870 (16 Stat. L., 229), requires that fuel purchased for the civil, military or naval service of the United States in the District of Columbia must be inspected and weighed or measured, and defines what constitutes a ton of coal and a cord of wood.

The act of December 22, 1870 (16 Stat. L., 397), provides that the Secretary of the Treasury shall prescribe and require that the true quality of imported sugar shall be ascertained and that the weights of sugar imported shall be marked on each package.

An act of June 6, 1872 (17 Stat. L., 237), prescribed the standard for measuring vinegar in the imposition of import duties.

An act of June 7, 1872 (17 Stat. L., 271), for the protection of seamen, requires every master of a vessel to keep on board and use proper weights and measures for "determining the quantities of the several provisions and articles served out" to seamen.

On September 20, 1886, the Commissioner of Agriculture submitted a report by William McMurtrie on the physical properties of wool and other animal fibres, made in pursuance of the provisions of an act of June 16, 1880 (21 Stat. L., 295). The work carried on by the author covered a study of all the important qualities of the fibres, including the "minute structure of the fibre of different breeds, its length, crimp, fineness, strength, elasticity, and the discussion of the relation of each of these properties to the others and to the breed, sex, age, and position of fleece represented." The report, which appears to be the result of very elaborate tests and researches, covers 613 quarto pages. The National Academy of Sciences published a "wool classification" in 1886.

Many of the laws, and regulations of the government relating to standardization and testing, and their enforcement, have necessitated the coöperative activities of the Office of Standard Weights and Measures of the Treasury Department long before the creation of the Bureau of Standards.

Compilation of Weights and Measures Laws. During the fiscal year ending June 30, 1890, the Office of Weights and Measures made a compilation of all the state laws relating to weights and measures, and also collected, through the Consular Service of the Department of State, information concerning weights and measures in 45 foreign countries.

Legal Status of the Former Office of Standard Weights and Measures. The Office of Construction of Standard Weights and Measures, later designated as the Office of Standard Weights and Measures, had its origin, at least as far as its activities are concerned, about the same time as the Survey of the Coast, now designated the Coast and Geodetic Survey, both offices having been under the same executive head until the creation of the present Bureau of Standards on July 1, 1901.

The functions of securing and comparing, and the custody of standard weights and measures were not originally prescribed by Congress, but were instituted by direction of the Secretary of the Treasury. When the Coast Survey work was undertaken, the necessity for obtaining accurate metrological instruments at once became so apparent that such instruments were purchased and constructed by and under the direction of Hassler, then Superintendent of the Coast Survey. The work first assumed general importance when, as a result of the investigation undertaken by Hassler in compliance with a Senate resolution of May 29, 1830, and reported by the Secretary of the Treasury, March 3, 1831, it was found that great discrepancies existed in the weights and measures used at custom houses, and the Secretary of the Treasury ordered the distribution of copies of the Treasury Department standards to the custom houses.

While this construction work was going on, Congress by a joint resolution approved June 14, 1836, ordered the Treasury Department to furnish each state with copies of these standards, and by act approved July 7, 1838, directed the Secretary of the Treasury to have a standard balance made for each state. While this involved considerable specialized work, there was no legal provision made at that time for the establishment of an office of weights and measures, although in the Treasury Department such an office virtually had a separate existence.

From the beginning, this section or office in the Treasury Department became the custodian of all the standards of weights and measures adopted by the Treasury Department, except the troy pound of the mint, which remained in Philadelphia. Upon the creation of the Bureau of Standards these standards were transferred to that Bureau.

The expenses of conducting the Offices of Weights and Measures and constructing the standards for the use of the government, the custom houses, the individual states, and others, were met until 1837 out of general appropriations for the Treasury Department. An act of March 3, 1837 (5 Stat. L., 169), made a general appropriation for the Coast Survey, which item was repeated in subsequent appropriation acts until 1870.

An appropriation act of July 15, 1870 (16 Stat. L., 303), made all the items for the Coast Survey specific, leaving no items out of which expenses for standard weights and measures could be met. The attention of Congress having been called to this omission, the appropriation act of March 3, 1873 (17 Stat. L., 514), had an item: "For construction and verification of standard weights and measures for the customhouses and for the several states, and of metric standards for the states, $12,000." This was the first time in the history of weights and measures in this country that an appropriation was specifically made for standard weights and measures. The same form of appropriation was continued in appropriations for subsequent years.

In an act approved June 20, 1878 (20 Stat. L., 216), the words "Standard weights and measures" appear in small capitals at the head of the paragraph making appropriation therefor, and this form was used until the act approved August 5, 1882 (22 Stat. L., 230), when the heading became "Office of Construction of Standard Weights and Measures." This was the first time that this office was mentioned as a separate unit in any legislative act.

The name "Office of Construction of Standard Weights and Measures" continued to be used in the appropriation acts until the absorption of this service by the National Bureau of Standards on July 1, 1901, although, since 1891, it was otherwise officially designated as "Office of Standard Weights and Measures," a name which was used when the office was mentioned in the organic act creating the National Bureau of Standards. The name of the latter was subsequently changed to "Bureau of Standards."

By the Act of July 11, 1890 (26 Stat. L., 242), the following addition to the functions of the Office of Construction of Standard Weights and Measures was provided for:

> Such necessary repairs and adjustments shall be made to the standards furnished to the several States and Territories as may be requested by the governors thereof, and also to the standard weights and measures that have been, or may hereafter be supplied to United States Custom-houses and other officers of the United States, under act of Congress when requested by the Secretary of the Treasury.

Between 1893 and 1901, appropriations were made "For construction and verification of standard weights and measures, including metric standards for the Custom houses, other officers of the United States, and for the several states, and mural standards of length in Washington, District of Columbia."

An appropriation for replacing lost standard weights and measures was made August 18, 1894 (28 Stat. L., 383).

Creation of the Bureau of Standards. With the development of science and the growing complexity of industry and commerce the need for stable and accurate standards not only of weight, length, and capacity but also of volume, power, and energy, became more and more apparent. The scientist, the merchant, the manufacturer, the consumer, and the public officer, all required to have recourse to such standards in scientific, industrial, and mercantile operations, and in the enforcement of laws.

There was urgent need for standards of a thousand and one forms and kinds as well as for apparatus for tests and comparisons. It was necessary to determine the accuracy of meters, balances, precise measuring apparatus, graduated glassware, pressure gauges, thermometers, barometers, various metrological apparatus, photometers, gas and water meters, apparatus for electrical measurements, oil testers, instruments used in surveying, navigation and hydrography, apparatus for testing the strength of materials, and a great variety of others. It became more and more important as science, industry, and commerce advanced that the graduations and indications of these instruments should agree with fundamental standards, and that such standards should bear the voucher of governmental supervision and control.

Other countries, and especially Germany, had for many years made long strides in the direction of supplying these standards, and it had become a practice for American scientists, merchants, and manufacturers and even for our government officers, who had need for such certified standardization, to send their instruments and apparatus abroad for testing and comparison. This involved much expense, delay, inconvenience, and some humiliation, but it was the only means of obtaining satisfactory standardization in many lines of metrology prior to 1901.

The earliest foreign official agency for the establishment of fixed accurate standards of weights and measures, was the "Normal-Aichungs-Commission" of Germany. It was established in Berlin in 1868, and its purpose was declared to be "to regulate the system of inspection of weights and measures throughout the North German Confederation; to construct and provide standards and the necessary measuring apparatus for the local bureaus; to fix regulations in regard to the system of inspection, and to provide for the safe custody of the standards."

In 1871 Austria established a "Normal-Aichungs-Commission"; in 1878, Russia established the Central Chamber of Weights and Measures, which was reorganized in 1893; and in 1879 England established the Standard Department, all of which institutions had functions similar to the "Normal-Aichungs-Commission" of Germany.

The earliest institution corresponding more nearly to the present Bureau of Standards is the "Physikalische-Technishe Reichsanstalt" established in 1887 at Charlottenburg, Germany, as a national physical laboratory and standardizing bureau.

The Kew Observatory, established in 1871 at Richmond, Surrey, England, originally as an astronomical observatory, and then as a meteorological observatory also, became, later, a general testing bureau, under the Royal Society of London. In 1899 the English National-Physical Laboratory was established as a government institution, and it took over the Kew Observatory. It then became a general standardizing laboratory where standards and measuring instruments in use in science and trade may be verified and research work may be undertaken when required for the needs of the laboratory or when regarded as of distinct value to the public generally. The Electrical Standardizing Laboratory was established in 1890 at Westminster, England, under the Board of Trade, its function being the "general electrical testing and the verification of electrical standards and measuring apparatus."

In the United States, the meagre provisions made by Congress for standardization work prior to 1901 made it impossible for the Office of Standard Weights and Measures to do more than render a very limited service to the national government and to the states and practically no service to private industry.

In order to get into line with other leading countries in meeting the demands of science and industry for standardization, the Secretary of the Treasury in 1900, submitted to Congress the draft of a bill providing for the establishment of a National Standardizing Bureau, with an appended statement of the conditions necessitating such legislation. This bill was introduced in the Senate (S. 4680) on May 14, 1900, and in the House of Representatives (H. R. 11350) on May 5, 1900.

The bill provided that the Office of Standard Weights and Measures should be known as the National Bureau of Standards, removing it from the supervision of the Superintendent of the Coast and Geodetic Survey, but leaving it for the time in the Treasury Department.

The functions of the proposed bureau, as specified in the bill, comprised:

1. Custody of the standards.
2. Comparison of the standards used in scientific investigations, engineering, manufacturing, commercial, and educational institutions with the standards adopted or recognized by the government.
3. The construction, when necessary, of standards, their multiples and subdivisions.
4. The testing and calibration of standard measuring apparatus.
5. The solution of problems which arise in connection with standards.
6. The determination of physical constants and the properties of materials when such data are of great importance and not to be obtained of sufficient accuracy elsewhere.

It was provided in the bill that the Bureau was to exercise its functions for the government of the United States, for any state or municipal government within the United States, or for any scientific society, educational institution, firm, corporation, or individual within the United States requiring the use of standards or standard measuring apparatus. Reasonable charges were to be made for its services except when rendered to the United States government or state governments within the United States.

The bill made provision for the purchase of a site and the erection of a suitable laboratory, and for its equipment with the most improved facilities. Provision was also made for the necessary personnel.

It further provided for a visiting committee composed of prominent specialists to be consulted "on all matters pertaining to the organization of the Bureau," the purpose being to insure thereby the establishment of an institution of the highest type.

The bill received the endorsement of all the technical bureaus of the government, the National Academy of Sciences, the American Association for the Advancement of Science, the American Physical Society, the American Chemical Society, the American Institute of Electrical Engineers, the Congress of American Physicians and Surgeons, the National Electric Light Association, and other prominent private organizations, scientific and engineering faculties of educational institutions, and manufacturers and users of scientific apparatus.

Hearings were held by the House Committee on Coinage, Weights, and Measures on May 3, 1900, and by the Senate Committee on Commerce, December 28, 1900, at which many of these organizations were represented, and letters were presented from every scientific bureau of the government, and from prominent scientists, manufacturers, and others, many of whom testified that they had been compelled to go abroad for certain standards.

After favorable reports had been made by both committees, the House bill, with some modifications, was enacted into law on March 3, 1901 (31 Stat. L., 1449).

In the interval between the enactment of the law, March 3, and the date when it was to take effect, July 1, 1901, preliminary plans were prepared by the Office of Standard Weights and Measures. This work was facilitated by the fact that the Inspector of Weights and Measures under the old régime, Dr. S. W. Stratton, was appointed Director of the newly created Bureau. Numerous sites for the laboratory were inspected with reference to their freedom from mechanical and electrical disturbances and their accessibility, and preliminary investigations were made of the construction and equipment of the more important laboratories of this and other countries, and plans were made concerning the work to be developed after the organization of the new Bureau.

At the time of the transformation of the Office of Standard Weights and Measures into the National Bureau of Standards, the office had only eight employees, comprising the inspector, who was the immediate executive head of the office, an adjuster, a verifier, a mechanician, an adjuster's helper, a stenographer, a watchman, and a messenger, with a total appropriation for the fiscal year 1901, of $9410 for salaries and $1475 for contingent expenses. The appropriations for the Bureau of Standards, as provided for in the organic act of March 3, 1901 (31 Stat. L., 1449), were $29,140 for salaries; $100,000 for the beginning of the construction of a laboratory, the total cost of which not to exceed $250,000, a limit which was gradually increased to nearly three-fold this amount; $25,000 for a building site; $10,000 for equipment; and $5000 for other expenses. Fourteen statutory positions were provided for.

Growth of the Bureau of Standards 1901 to 1917. Immediately upon its creation in 1901 many demands were made upon the Bureau for its services, and Congress, by increasing its appropriations from year to year enabled the Bureau to enhance its facilities and expand its work. From time to time additional experts were employed, new buildings were erected and apparatus and materials were acquired. The direction of the Bureau's growth was determined by the relative urgency of the several lines of its activities.

During the first few years of the existence of the Bureau of Standards, appropriations for its activities were made in general terms only; that is, for salaries, equipment, etc., but in the appropriation act of March 4, 1909 (35 Stat. L., 903), for the fiscal year ending June 30, 1910, Congress began making itemized appropriations for specific activities—a practice which has grown to such proportions that for the fiscal year ending June 30, 1925, twenty-four such itemized appropriations were made, aggregating $1,148,800 out of a total appropriation of $1,775,760 for the Bureau.

Soon after the creation of the Bureau of Standards, a site of seven and one-half acres in the northwest section of Washington was selected for its buildings, in a neighborhood which is free from outside mechanical and electrical disturbances, and where the zoning regulations of the District of Columbia will prevent the erection of any future private industrial plants.

During the first two fiscal years of its existence, the Bureau occupied temporary quarters, pending the construction of a mechanical and a physical laboratory on the purchased site. In the meantime the efforts of the Bureau personnel were directed toward the organization of the work; the planning of many new lines of activity; the designing, construction, and purchase of the necessary apparatus for carrying it on; and the comparing and testing of such standards and measuring instruments as could be done in the temporary quarters with the limited facilities at hand.

Section 4 of the act of February 14, 1903 (32 Stat. L., 825, 826), which established the Department of Commerce and Labor, provided for the transfer of the National Bureau of Standards from the Treasury Department to the Department of Commerce and Labor. The name was changed to Bureau of Standards on

July 1, 1903, by order of the Secretary of Commerce and Labor, but neither of these changes affected the status or functions of the Bureau.

The year 1904 found the Bureau in the full activity of its expanded field of work. The mechanical laboratory having been completed early in that year and the physical laboratory a little later on, the entire work of the Bureau was transferred to the new quarters in November and December, 1904. The increased facilities thus afforded, enabled the Bureau to begin the extension of the range of its work which theretofore had been mainly confined to the field of weights and measures.

Many new lines of testing were begun about this time, tests being made for practically all departments of the government; for state sealers of weights and measures; for electrical companies; for manufacturers of mechanical standards, thermometers, weights and measures; and for the general public. Much attention was given to the designing of apparatus and standards for various kinds of tests, and to research concerning fundamental problems connected with fixing the standards and determining methods of measurement. About this time, the Bureau began the publication of circulars descriptive of the lines of testing which it was prepared to undertake.

In its original field of work, that pertaining to weights and measures, the Bureau continued its many tests. It compared in that year, the United States prototype meter with the international meter of Paris; planned a convention of state sealers of weights and measures; determined methods of calibrating volumetric apparatus; developed plans for standardizing time-measuring instruments; supervised an examination that was being made of the weights and measures and methods of measurement at custom-houses, tested and distributed to the latter weighing and measuring instruments, fixed preliminary limits of tolerance, and developed a plan for the systematic inspection of such instruments. In 1905 the Bureau mounted a new twenty-five kilogram balance, which was about fifty times as sensitive as the one which had previously been used. Important instruments of precision were also constructed.

The electrical work done in the new mechanical laboratory in 1904 included calibration of resistance and standard cells, the determining of inductances and capacities, the testing of electrical instruments, photometric work, and researches concerning the development of more refined methods of electrical testing.

The Bureau during that year rendered important service to makers and users of thermometers and pyrometers by testing such instruments in a specially equipped laboratory, and by investigating the various types of high-temperature measuring instruments.

Other activities in which the Bureau was engaged at this time included a study of polariscope methods of sugar analysis for the customs service, testing engineering instruments, investigating screw threads of fire hose couplings, preparing standard specifications for the purity of chemical reagents, and planning and equipping a chemical laboratory.

All these and other activities were carried on with an appropriation of $537,640 and a force of about seventy persons. From year to year, as increased appropriations were made by Congress, the personnel and the laboratory facilities were largely increased, and the work in these and other new lines of endeavor was very materially expanded.

Upon the initiative of the Bureau a conference on weights and measures was held in January, 1905, which was attended by the sealers of weights and measures of the various states. The representatives at the conference were shown a collection of weights and measures and balances suitable for their use, and an effort was made to demonstrate to them the importance of the work of testing commercial weights and measures. The conference awakened an interest throughout the country in the use of correct standard weights and measures and marked the beginning of an organized movement for uniform legislation and regulation on this subject.

The completion and equipment of a chemical laboratory in March, 1905, facilitated the carrying on of the Bureau's work upon standards of purity for chemical reagents and standard methods of technical analysis, and the physical and chemical examination of a number of substances with the view of determining standards and standard specifications to be employed in the purchase of government supplies.

After its establishment in the new quarters during 1905, the electrical work of the Bureau assumed increased importance. The activities in this field were divided into five principal groups or sections, those having to do with: (1) Resistance and electromotive force; (2) magnetism; (3) inductance and capacity; (4) electrical measuring instruments; and (5) photometry. Several investigations relating to fundamental electrical units and standards were begun during this year.

In 1906 a low temperature laboratory was completed. This is of especial value in establishing the standard scale of temperature for verifying low temperature apparatus, and it permits important research in other kinds of measurement at temperatures not previously available.

A comparison was made, in 1906, of the photometric standards of this country with the standards of England, France, and Germany, and preparations were made for a study of primary photometric standards, new apparatus for most accurate measurements having been installed in the photometric laboratory.

By the completion in March, 1906, of a fifty-meter comparator for testing geodetic measuring apparatus, the Bureau was enabled to render exceptional service to the Coast and Geodetic Survey and to similar institutions in other countries. The Bureau's equipment for such work was said to be better at that time than that of any other institution in the world.

At the third conference of weights and measures held in April, 1906, a model law for adoption by the states was outlined and recommended.

During the fiscal year 1907 a platinum-iridium meter bar was purchased from the French government. It was sent to Geneva, for graduation into millimeters, and thence to the International Bureau of Weights and Measures in Paris, for comparison.

An extended investigation of the standards of electromotive force and the method of their preparation was completed during that year, and other investigations were either completed or in progress concerning the ratio between certain electrical units, the absolute measurement of resistance and the various methods of measuring magnetic properties of materials. The Bureau in the same year coöperated in a conference between government engineers and lamp manufacturers, the result being the adoption of specifications for the purchase of incandescent lamps by most of the government departments.

In thermometry, pyrometry, and heat measurement the Bureau completed during 1907 a study of the standards on which are based the standard temperature scale from 0° to 100° C., and it determined the melting points of certain metals, these being fundamental points in the measurement of high temperatures.

During the same year, at the request of the American Foundrymen's Association and the Association of American Steel Manufacturers the Bureau undertook the analysis and distribution of standard steel and iron samples which are used by these industries to standardize and check their own analyses from time to time. The Bureau also coöperated with the American Chemical Society with respect to securing uniformity in technical analysis and improving the quality of chemical reagents.

On May 22, 1908, an appropriation of $175,000 was made by Congress " for the construction of a fire-proof laboratory to provide additional laboratory space for the Bureau." Although this new building, which was completed in 1910, nearly doubled the capacity of the Bureau, the work had so outgrown its existing quarters that all the laboratory space in the new building was immediately utilized.

The acts of May 23, 1908 (35 Stat. L., 256), June 30, 1914 (38 Stat. L., 421), and August 11, 1916 (39 Stat. L., 476), made provision for the establishment and promulgation of cotton standards by the Secretary of Agriculture. These acts, however, have no relation to the work of the Bureau of Standards.

In October, 1908, an electrical commission met at London, and adopted a new value for the unit of electromotive force. A new international committee on electrical units and standards was appointed, three of whom were officers of the Bureau of Standards, to prepare specifications for the concrete standards.

An extended investigation of the action of platinum resistance thermometers at high temperatures was completed in 1909. These instruments are used to control various chemical operations, hardening and annealing temperatures in the arts and industries.

The same year the testing of water-current meters for the use of hydraulic engineers in gauging streams was undertaken.

The Bureau during the fiscal year ending 1909 succeeded in securing a tentative agreement upon a uniform international unit of light in England, France, and the United States, and the adoption of this unit in the gas and electrical industries in this country.

The same year the Bureau arranged with the American Brass Founders' Association, at its request, to furnish standard analyzed samples of brass to improve the methods of brass analysis.

As already mentioned, until the year 1909, appropriations for the current work of the Bureau of Standards were made in general terms. In the act of March 4, 1909 (35 Stat. L., 903), making appropriations for the fiscal year 1910, additional appropriations were made for the first time for specific activities. In this act an appropriation of $10,000 was made for each of the two following activities:

> For the investigation of the Pentane, Hefner, and other flame standards used in the measurement of the illuminating power of gas, and determining the accuracy practically obtainable in such measurements; also for the determination of the heat of combustion of certain gases which occur in illuminating gas, which are used as a basis for computing the heat value of the gas, and for the determination of the heat combustion of materials employed by engineers in the standardization of industrial calorimeter.
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> To enable the Bureau to collect information relative to the weights and measures used in trade and to aid state sealers and other officers in adopting standard practice as to the establishment of tolerances, methods of inspection and sealing, and other technical details necessary to insure correct weights and measures in commerce and trade.

A deficiency appropriation of $10,000 was made on June 25, 1910 (36 Stat. L., 801), for the continuance of this last-mentioned work. Two inspectors visited many cities and towns in the several states, assisting the state and local authorities in the improvement of the laws, regulations, and practices concerning the weights and measures used in ordinary trade and commercial transactions.

Another act approved March 4, 1909 (35 Stat. L., 893), appropriated $50,000 " Toward procuring a testing machine to cost not exceeding $150,000, and for services in connection therewith, for the determination by the Bureau of Standards of physical constants and the properties of materials as authorized by law." This appropriation was made immediately available, and plans and specifications for a large Emery testing machine were soon after completed. The machine was built during the following year, a special appropriation of $130,000 in addition to the original $50,000 having been made for this purpose by the Act of February 25, 1910 (36 Stat. L., 216). Appropriations for determining physical constants have been repeated for each subsequent fiscal year.

The tariff act of August 5, 1909 (36 Stat. L., 14, 35, 39, 65), defined the weight per gallon of certain vegetable oils; the weight per bushel of certain agricultural products and provisions; the proof gallon of vinegar, and the weight per bushel and per ton of coal.

During April and May, 1910, delegates from the Physikalisch-Technische Reichsanstalt of Germany, the National Physical Laboratory of England, and the Laboratoire Central d'Électricité of France, and representatives of the Bureau of Standards, carried out in the laboratory of the Bureau in Washington, an investigation with the view of securing international uniformity to a high degree of precision in the three fundamental electrical units, namely, the ohm, the volt, and the ampere. A careful series of experiments on the silver voltmeter, measurements on standard cells, and standards of resistance were made, intercomparing those brought from foreign national laboratories and those of the Bureau of Standards, and also comparing the types of silver voltmeters used in the several countries. As a result of these studies, the International Committee on Electrical Units and Standards later recommended the adoption of a new value for the international volt, which was accordingly done in England, France, Germany, and many other countries. It was adopted in the United States on January 1, 1911.

During the fiscal year 1910, the Bureau, at the invitation of the American Mining Congress, made a study of the standardization of electric machines and electric practice in mines, the report of which was published together with model regulations drafted to meet the technical requirements for such standardization.

In the same year, the troy pound of the mint was verified, the change found from the value given in 1827 being only about 0.005 grain. A set of platinum weights calibrated at the Physikalisch-Technische Reichsanstalt of Germany on test by the Bureau showed agreement with the results at the Reichsanstalt within a few thousandths of a milligram. On March 4, 1911, an act (36

Stat. L., 1354), was approved providing that the old troy pound of the mint at Philadelphia be superseded by the standard of the Bureau. As a result, there is now a single standard of mass for all purposes in the United States. This in no wise changes the actual value of the mint weight, but substitutes the platinum-iridium kilogram for the old brass mint pound as the fundamental standard. The act also requires the procuring and maintaining of such standard weights at the mints and assay offices, and directs the annual testing of the weights ordinarily employed.

As a result of a study of the density and thermal expansion of alcohol and its mixtures with water by the Bureau of Standards, the inexact tables formerly used in alcoholometry were corrected. An idea of the value of this study may be obtained when it is realized that on the basis of such tables approximately $200,000,000 of government revenues were being collected at that time.

In 1910 the Bureau undertook an investigation of the effects of electric currents upon gas and water pipes, and upon reinforced foundations of buildings, bridges, and other structures in order to determine methods of discovering and preventing the effects of such currents. Special appropriations were made for this work in the act of June 17, 1910 (36 Stat. L., 528), and in two subsequent appropriation acts.

An act of May 16, 1910 (36 Stat. L., 369), establishing the Bureau of Mines in the Department of the Interior, made provision for the transfer of the work of investigating structural materials belonging to and for the use of the United States, from the Geological Survey to the Bureau of Mines. This provision was repealed by a clause in the sundry civil appropriation act of June 25, 1910 (36 Stat. L., 743). The same act made an appropriation of $50,000 for the continuation of this work by the Bureau of Standards, thus virtually transferring it to that Bureau where it has since remained. As a result of this legislation, the laboratories, equipment, and personnel for this work were formally transferred. Before the transfer, the work had been carried on by the Geological Survey in four laboratories—tests and investigations of ceramics, cements, lime, steel, and miscellaneous structural materials in Pittsburgh; tests of structural and miscellaneous materials, in Washington, mainly for the Supervising Architect's Office; tests of cement, at Northampton, Pa., principally for the Isthmian

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Canal Commission; and an investigation of the effect of sea water upon concretes and protective coatings, at Atlantic City. The equipment transferred consisted of one 100,000-pound, three 200,000-pound, and one 600,000-pound testing machines, and a new 10,000,000-pound Olsen testing machine, as well as various smaller machines for testing cement and clay products, together with miscellaneous laboratory apparatus and office furniture. The testing work and investigations in progress at the time of the transfer were continued, but some changes were made in the arrangement of the laboratories and the distribution of the work. While the testing was not disturbed by the transfer, it was necessary to devote considerable time to reorganizing the work and coördinating it with the similar established testing work of the Bureau.

The appropriation for testing structural materials has been repeated each year, and has been greatly increased, the last appropriation for the fiscal year 1926 being $230,000.00.

As a result of a coöperative investigation made previously at the Bureau, it adopted on January 1, 1911, the new value for the international volt in accordance with a recommendation of the International Committee on Electrical Units and Standards. Many other countries, including England, France, and Germany, adopted the same standards, thus securing, for the first time, close international agreement in the measurement of electrical voltage and current. The construction of four primary mercurial resistance standards in accordance with the specifications adopted by the London International Electric Conference of 1908 was practically completed about this time.

The Bureau in 1911 made an investigation of various types of locomotive headlights, in order to furnish data on which a fair interpretation of legislative regulations on that subject might be based. Investigations were also made of arc and gas-lamps used in the streets and in parks of the District of Columbia, which resulted in the modification of such lamps and the consequent increase of 50 per cent of light without additional cost. At the request of the Supervising Architect of the Treasury, tests were made in 1911, covering a period of six months, of a number of different systems of master and secondary clocks suitable for installation in public buildings. The results of the test are utilized by the Supervising Architect in awarding contracts for the installation of clock systems in government buildings.

During the year 1911 the investigation of trade weights and measures conditions throughout the country was practically brought to completion, every state in the union except Arkansas and Oklahoma having been visited by inspectors of the Bureau. During the two years of the investigation 8630 scales were tested, of which 42 per cent were found to be incorrect; 10,929 weights were tested, of which 20 per cent were incorrect; 6088 dry and liquid measures were tested, of which 33 per cent were incorrect. Following this investigation thirty-five state legislatures gave consideration to bills either to establish weights and measures laws, or amending those already on the statute books, and twenty-five enacted important legislation on the subject. To obtain uniformity, a model state law was drafted by the Bureau, which, with minor modifications to suit local conditions, has been adopted in a number of the states. A model weights and measures ordinance for municipalities was also drafted by the Bureau.

The need for national legislation concerning weights and measures disclosed by this investigation furnished the incentive for the Director of the Bureau to call attention in his annual report for 1911 to the provisions of the Constitution concerning standard weights and measures and to recommend the following legislation:

1. A national law defining and fixing the usual weights and measures that may be used in every-day trade.
2. A law fixing the sizes of the more common shipping units, such as barrels, bales (of cotton), boxes, baskets (of fruit), etc.
3. A law requiring the net weight, measure, or numerical count to be plainly stated upon the outside of all commodities put up in sealed packages.
4. A law to eliminate the manufacture and sale of apparatus designed to facilitate fraud.

At the request of the Navy Department a course of lectures was given by a staff member of the Bureau before the officers of the School of Marine Engineering at Annapolis, in 1911.

An act of March 4, 1911 (36 Stat. L., 1231),[81] made provision for the designation of an acting director to perform the duties of

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[81] See page 250.

Director in his absence. In the same act substantial appropriations were made for the construction of additional laboratories and the installation of machinery on the Bureau's site in Washington and at the Pittsburgh branch.

During the fiscal year 1912 the Bureau, in coöperation with the executive departments, secured the adoption, for the entire government, of standard specifications for Portland cement. The Bureau the same year prepared copper-wire tables which have since been adopted as standard by the copper-wire industry.

At a meeting of the International Committee for Uniform Methods of Sugar Analysis held at New York in 1912 a representative of the Bureau presented a paper on the basis of standardization of the sugar testing polariscope, calling attention to an error in the existing method of measurement. This presentation resulted in the appointment of a special commission to investigate and make recommendations concerning the same. The institutions represented in the committee were the Bureau of Standards, the Austrian Sugar Institute, the German Sugar Institute, and the German Physikalische-Technische Reichsanstalt.

On August 3, 1912 (37 Stat. L., 250), an act was approved "to establish a standard barrel and standard grades for apples when packed in barrels." While there is no provision in the act directly concerning the Bureau of Standards, it is a standardization measure in line with the Director's recommendations.

An act of August 24, 1912 (37 Stat. L., 477), appropriated $85,000 for the acquisition of additional land for the use of the Bureau, of which about $68,000 was actually expended.

An appropriation of $15,000 was made in the same act (p. 476) for the fiscal year 1913 "for investigations incident to the establishment of units and standards of refrigeration and the determination of the physical constants of materials used in the refrigeration industries, such as ammonia, aqueous ammonia solutions, carbonic acid, brines, and so forth, and the determination of the thermal conductivities of materials." This appropriation was repeated in each of the fiscal years 1914 to 1917.

The construction of a current meter water tank and of a new electrical laboratory were authorized by acts of August 23, 1912 (37 Stat. L., 410), and March 3, 1913 (37 Stat. L., 788), respectively.

In line with a recommendation made by the Director in his annual report for 1911, an amendment to the food and drug act of June 30, 1906 (34 Stat. L., 771), was enacted March 3, 1913 (37 Stat. L., 732), requiring that the net weight, measure, or numerical count shall be plainly and conspicuously marked on the outside of all packages containing food, thus giving the consumer a direct knowledge of the net quantity of product in a large proportion of his purchases. A member of the staff of the Bureau of Standards represented the Secretary of Commerce on an interdepartmental committee of representatives of the Secretaries of Commerce, the Treasury, and Agriculture, appointed to draft rules and regulations for the enforcement of this amendment.

Another act in line with the Director's recommendations was approved March 4, 1915 (38 Stat. L., 1186), known as "the standard barrel law." This act fixes a standard barrel and subdivisions for fruit, vegetables, and other dry commodities, and makes it a misdemeanor to sell in less capacity than the standard. Its provisions apply to both interstate and intrastate transactions. It is the first mandatory though not exclusive standard for general commercial use that was ever established by Congress under the power given that body, with regard to weights and measures, by the Constitution. The technical administration of the standard barrel law was entrusted to the Bureau of Standards, and the latter was empowered, by the act, to establish certain tolerances and to make rules and regulations for its enforcement. The act is designed to ameliorate to some extent the confusing effect on commerce of the manifold varieties of barrels used for various purposes.

In the same Congress which enacted this law a bill was introduced "to regulate and control the manufacture, sale, and use of weights and measures," in accordance with the Director's recommendations, but the bill was not enacted.

An act of March 4, 1913 (37 Stat. L., 945), making appropriation for the District of Columbia, requires that materials for fireproof buildings and all other materials, except for paving and for fuel, purchased for the use of the government of the District of Columbia, should be tested by the Bureau of Standards when deemed necessary by the Commissioners.[32]

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[32] See page 251.

In 1913 the Bureau began the work of testing master scales and general railroad track scales throughout the country, an appropriation of $25,000 having been made March 4, 1913 (37 Stat. L., 787), " for the investigation and testing of railroad, elevator and other scales used in weighing commodities for interstate shipment . . . and for the purchase of a test car and standard scale of 60,000 pounds capacity." The importance of this work is manifest when it is realized that the vast freight revenue of all the railroads amounting to about $4,000,000,000 annually is based upon the weighing of such scales. This work, which by virtue of subsequent annual appropriations became a regular function of the Bureau and has been continued to the present time, assumed especial importance when the government took over the control of railroads during the World War. The Bureau's work consists of testing master scales by which local track scales are adjusted, advising as to methods of operating such scales and keeping them in effective condition, and settling disputes arising out of freight weighings. In subsequent acts the scope of work authorized under this appropriation was greatly extended so as to include practically all the weights and measures activities of the Bureau.

In 1914 a general agreement was reached and a program was outlined for coöperation and correlation of work in the investigation of the stone resources of the country, by an advisory committee representing the Bureau of Standards, the Bureau of Mines, and the Office of Public Roads.

An advisory committee, consisting of representatives of the government and of engineering societies, the Lime Manufacturers' Association, Cement Manufacturers' Association, Gypsum Industries Association, and Metal Lath Industries Association, was organized during the fiscal year 1914 to coöperate in a comprehensive investigation of the durability of stuccos and plasters, the purpose being to obtain information concerning methods of preventing the cracking of stucco, to ascertain the durability of various kinds of metal lath, the cause of discoloration of plasters, the proper mixtures to be used, etc. This investigation was carried on for a number of years and involved both laboratory and field work.

A representative of the Bureau, in the same year, was made a member of a subcommittee of the International Association for

Testing Materials, to which inquiries of a chemical nature concerning pig iron are referred.

An investigation of "the danger to life and property due to the transmission of electric currents at high potentials and the precautions to be taken, and the best methods of construction, installation, and the operation to be followed in the distribution and return of such currents in order to diminish such dangers," also of "the best means of protecting life and property from lightning," was undertaken by the Bureau as a result of an appropriation of $15,000 for that purpose, by an act of March 4, 1913 (37 Stat. L., 787). Appropriations for the continuance of this investigation were made for each of the five succeeding years.

In carrying on this work, the Bureau coöperated with the National Fire Protection Association in the preparation of safety rules to be observed in the construction and operation of electric light and power plants, and in the distribution and utilization of electricity. The code was originally published in two installments for examination and criticism, the operating rules in August, 1914, revised in May, 1915; and the construction rules in April, 1915. Both were again revised after a general conference of all interests in Chicago in the spring of 1916, and published by the Bureau in a single volume (Circular No. 54) the following November. The circular has since been revised and reprinted.

An appropriation of $25,000 was made in the same act and repeated each subsequent year, "for the investigation of fire resisting properties of building materials and the conditions under which they may be most efficiently used." The Bureau commenced this work, in 1913, which has since become one of its regular functions. It covers the planning and carrying out of high-temperature measurements, fire tests of structural materials, the determination of their thermal conductiveness, etc.; problems relating to the preparation and testing of concretes, tiles, bricks, steel-structural material, etc.; safety rules for electrical wiring and other problems pertaining to the national electrical code; and the behavior of structural materials under heat as to expansion, etc. This work requires the coöperation of nearly every one of the scientific and engineering laboratories of the Bureau.

In 1913 the Bureau began making application of its special technique for hypersensitizing photographic plates so that they would photograph landscapes through fog, an activity which was continued for many years.

On June 23, 1913, an act (38 Stat. L., 66) was approved appropriating $45.000 " for the construction of a suitable fire-proof workshop and storehouse for the use of the Bureau of Standards.

In February, 1914, a conference of watchmakers was held at the Bureau for the discussion of proposed regulations for testing watches. As a result of the conference the testing of high-grade watches for the watchmaking industry was begun in April following, a fee being charged for such tests.

At the request of the Bureau of Insular Affairs, the Bureau of Standards in 1914 detailed one of its experts to organize an inspection department of weights and measures for Porto Rico under a territorial act of August 18, 1913, requiring the inspection of all commercial weights and measures in use under the supervision of the Secretary of Porto Rico.

The Bureau in 1914 established new standards of measurement, those of radiation. These new standards are incandescent lamps, the intensity of radiation of which was measured in terms of the simple units of measure by which energy is defined.

On acount of the outbreak of the World War in 1914, the importation of many necessary foreign products was cut off, and the Bureau immediately strove in every way possible to aid manufacturers to introduce new methods, to use new materials, and to develop new processes in order to supply the need.

In the pottery industry, for example, as a direct result of the work of the Clay Products Division of the Bureau of Standards then located at Pittsburgh, two American concerns undertook the production of chemical porcelain on a commercial basis and produced ware of a satisfactory quality.

The same division in July, 1914, undertook the experimental manufacture of optical glass and succeeded in producing a superior grade article, something never before made in this country.

The Bureau also succeeded in duplicating enamels for iron ware and special kinds of imported papers, among other things.

For the fiscal year 1915, the Bureau obtained special appropriations for three new activities, all of which were provided in the act of July 16, 1914 (38 Stat. L., 503).

One of these appropriations was "for the investigation of the standards and methods of measurement of public utilities, such as gas, electric light, electric power, water, telephone, and electric railway service, and the solution of the problems which arise in connection with standards in such service, $25,000." This investigation became a permanent function of the Bureau, materially increasing appropriations having been made for it annually up to the present time.

Another appropriation was "for the investigation of the materials used in the construction of rails, wheels, axles, and other railway equipment, and the cause of their failure . . . , $15,000," which was repeated for each of the fiscal years 1916 to 1921 inclusive.

The last of these items of appropriation was "for the testing of miscellaneous materials, including the supplies for the Government departments and independent establishments, . . . as authorized by law, $20,000." This appropriation was repeated for each subsequent year and increased to $44,090 for the fiscal year 1926.

The same act (p. 502) made provision for the promotion of apprentices in the Bureau of Standards with the approval of the Civil Service Commission.

A continuing appropriation of $25,000 "toward the construction of a suitable fire-proof chemical laboratory, to provide additional space, at a cost not exceeding $200,000," was made by an act of August 1, 1914 (38 Stat. L., 665). The balance of $175,000 was appropriated in installments during the three following years. Additional appropriations of $35,000 were made for each of the fiscal years 1916 and 1917, for the equipment of the new laboratory. On September 13, 1915, the contract authorized in the act of 1914 was entered into for the construction of the laboratory at a cost of $188,556, and the work of construction was immediately begun. The laboratory was completed and occupied in June, 1917.

Radio research was first made the object of a special appropriation by the act of March 4, 1915 (38 Stat. L., 1044), for the fiscal year 1916: "For investigation and standarization of methods and instruments employed in radio communication . . . , $10,000." This item of appropriation was repeated for each subsequent fiscal year, the amount being gradually increased to $44,800 for 1926. The Bureau had previously coöperated with other branches of the government in radio research, but this appropriation, though small, offered facilities for more effective work. On July 1 of the following year an act (39 Stat. L., 324) was approved making an appropriation of $50,000 "for construction of a fire-proof laboratory building to provide additional space to be used for research and testing in radio communication and to enable the Bureau of Standards to provide space and facilities for coöperative research and experimental work in radio communication by the War, Navy, Post Office, Treasury and other departments, and for suitable aerials, $50,000." Another appropriation of $40,000 for this purpose was made the following year.

Upon the enforcement of the Standard Barrel Act of March 4, 1915,[33] which became effective July 1, 1916, it was demonstrated by the lime industry that a standard-weight barrel would be more equitable to their trade, and as a result the Bureau assisted the National Lime Manufacturers' Association in framing a bill to regulate such measurement in this industry. This bill was enacted August 23, 1916 (39 Stat. L., 530), and went into effect at once, except the penal provision, which became effective on January 1, 1917. This law regulates the sale of lime by establishing two mandatory standard barrels for use in interstate commerce, containing respectively, 280 and 180 pounds net, and by requiring that packages of less capacity shall have the net weight of the contents stamped upon them. The law provides that the Director of the Bureau of Standards, with the approval of the Secretary of Commerce, should make the rules and regulations for its enforcement and specify the tolerances to be allowed.

A circular (No. 60) was issued during the fiscal year giving a comprehensive and up-to-date treatment of the various units of electrical measurement and the standards by means of which the units are maintained. It describes the present status of the fundamental electrical standards and the laws on electric units in the various countries of the world, which are now in substantial agreement.

After three years' study, and after coöperation with, and a general conference of, organizations interested, the Bureau completed and published in November, 1916, a national electrical safety code (Circular No. 54) of: (1) Rules for the installation of machinery, switchboards, and wiring in central stations and substations; (2) rules for the construction of overhead and underground lines for the transmission and distribution of electrical energy and intelligence; (3) rules for the installation of electrical apparatus and wiring in factories, and wherever electricity is utilized for light, heat, and power; (4) rules to be observed by employees in working on or near electrical machines or lines. It is intended for adoption by state, industrial, and public service commissions and municipalities, and to be complied with by public service and industrial corporations.

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[33] See page 251.

Before its publication in 1916, the code was published in two installments for examination and criticism: the operating rules in August, 1914, and a revision in May, 1915, and the construction rules, in April, 1915. A new edition of the Electrical Safety Code (Handbook No. 3) was published under date of October 31, 1920, but was not issued until early in 1921. A discussion of the code was published about the same time (Handbook No. 4).

During the fiscal year 1916, the Bureau, after several years' research work, devised and published a method of determining the properties of irons and steels by magnetization. As the magnetic properties bear a direct relation to the physical and mechanical quality of these metals, any flaw in the metal shows itself in the graphic curve automatically plotted by the magnetic instruments used. This method tests the whole amount of the material and not the surface only, and leaves the test piece unaltered.

A naval appropriation act of March 3, 1915 (38 Stat. L., 930), establishing a National Advisory Committee for Aeronautics to be appointed by the President, directs that one of these members shall be a representative of the Bureau of Standards. Both the present Director and the former Director of the Bureau of Standards are members of this committee.

Four new investigations were provided for in the appropriation act of May 10, 1916 (39 Stat. L., 115), for the fiscal year 1917, relating respectively to color standards, clay products, physical properties of materials, and the standardization of mechanical appliances.

The first of these items was an appropriation of $10,000, "to develop color standards and methods of manufacture and of color measurement, with special reference to their industrial use in standardization and specification of colorants, such as dyestuffs, inks, and pigments, and other products, paint, paper, and textiles, in which color is a pertinent property." This activity has become a regular function of the Bureau, the appropriation for this item having been continued for each subsequent fiscal year.

The pottery item of this act was for $10,000, which was continued for each subsequent year and increased to $27,000 for 1926. The appropriation was made to enable the Bureau "to study methods of measurement and technical processes used in the manufacture of pottery, brick, tile, terra cotta, and other clay products, and the study of the properties of the materials used in that industry."

The third item, to enable the Bureau "to determine experimentally important physical constants of materials essential to the industries or in laboratory investigations, as authorized by law . . . , $5000," was repeated for the three subsequent fiscal years, after which it was discontinued. The appropriation for standardizing mechanical appliances authorized the expenditure of $10,000 by the Bureau to enable it "to develop methods of testing and standardizing machines, motors, tools, measuring instruments, and other apparatus and devices used in mechanical hydraulic and aeronautic engineering; for the comparative study of types of apparatus and methods of operation, and for the establishment of standards of performance; for the accurate determination of fundamental physical constants involved in the proper execution of this work; and for the scientific experiments and investigations needed in solving the problems which may arise in connection therewith, especially in response to the requirements of aeronautics and aviation for information of a purely scientific nature." This appropriation was continued for each subsequent year, and was increased to $27,800 for the fiscal year 1926.

The production of optical glass became the subject of a special appropriation in an act of March 3, 1917 (39 Stat. L., 1116), for the fiscal year 1918. This item provided for "the investigation of the problems involved in the production of optical glass . . . , $10,000." It was repeated for varying amounts for each subsequent year, the amount appropriated for 1926 being $20,520.

The Department of Agriculture appropriation act of August 11, 1916 (39 Stat. L., 482, 489), has a provision entitled "United

States Grain Standard Act" which authorizes the Secretary of Agriculture to fix and establish "standards of quality and condition for corn (maize), wheat, rye, oats, barley, flax seed, and such other grains as in his judgment the usages of the trade may warrant and permit." Another provision of the same act authorizes the Secretary of Agriculture to establish and promulgate standards for other agricultural products. An act of August 31, 1916 (39 Stat. L., 673), fixes standards for Climax baskets for grapes and other fruits and vegetables, and for baskets and other containers for small fruits, berries, and vegetables, and requires conformity with such standards in interstate shipments. The enforcement of these two acts comes under the jurisdiction of the Secretary of Agriculture.

Activities During the World War. Immediately upon the declaration of war against Germany in 1917, the Bureau of Standards began to devote itself to war activities, and during the period of hostilities practically all the time and energy of the personnel of the Bureau were devoted to problems connected with the prosecution of the war. Some of the most important of these activities were such that for military or other reasons their nature and results could not be published. The others were so numerous and varied that only some of the more important can be mentioned.[34]

These war services consisted largely of making scientific tests and researches for the various military and civil authorities and scientific and industrial organizations engaged in war activities; examining and giving technical advice concerning plans and inventions designed for the use of the army and navy; and coöperating in other ways with governmental organizations and committees where the advice and facilities of the Bureau cauld be utilized for successfully carrying on the war. To this end Congress made very substantial appropriations, and liberal allotments were made from the National Security and Defense Fund.

The tests and researches were devoted chiefly to the development of new materials and devices, such as optical glass and optical instruments, and activities in the fields of aeronautics, metallurgy, electricity, and chemistry. They extended, however, far beyond the military fields, and produced results of permanent value to science and industry.

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[34] An elaborate report of 299 pages has been issued "War work of the Bureau of Standards," dated April 1, 1921. See page 276.

New materials had to be developed and existing materials had to be put to new uses, when the supply of many necessary raw materials was reduced or cut off by the war. For example, the shortage of linen resulted in the development by the Bureau of a satisfactory cotton fabric for use in covering airplane wings; a filter paper for gas masks was produced; and many specifications were prepared for all sorts of materials, such as prepared roofings, wall board, plaster board, cement, concrete, etc.; the Bureau developed new paints designed for the protection of the interior of shells and the holds of vessels, and water-proof glues, varnishes, dyes, and fabrics most effective in camouflage.

One of the most urgent needs of the war was the standardization of instruments, devices, and materials, and the urgent deficiency act of June 15, 1917 (40 Stat. L., 216), made provision for this purpose in two items, namely: " to enable the Bureau of Standards to coöperate with the War and Navy Departments by providing the scientific assistance necessary in the development of instruments, devices and materials, and the standardization and testing of supplies . . . , $250,000"; and "to provide by coöperation of the Bureau of Standards, the War Department, the Navy Department, and the Council of National Defense, for the standardization and testing of the standard gauges, screw threads, and standards required in manufacturing throughout the United States, and to calibrate and test such standard gauges, screw threads, and standards, including necessary equipment . . . , $150,000."

Both these appropriations were made immediately available. The first, which was known as the appropriation for "military research," was repeated in two appropriations the following year, the amounts totaling $350,000. The appropriation for gauge standardization has been repeated for each subsequent year, up to the present time, but the amount which varied from year to year, was materially reduced after the close of the World War.

The Bureau, profiting by the experience of the national testing laboratories of Europe, immediately upon our entry into the war began to make preparations for the certification of gauges used in the manufacture of munitions, and undertook investigations both in the United States and Canada. A building was fitted out for this purpose, new apparatus was installed, and an increased force was employed. The Bureau further arranged for the immediate testing of all weights needed for war purposes that might be submitted either by the various government departments or by private concerns.

Laboratory investigations were undertaken, in coöperation with military authorities, for the comparative study of the errors in the gauges used as speed indicators and other aeronautic measuring instruments, the Bureau being represented on a subcommittee of the National Advisory Committee in connection with this work.

Many electrical investigations of a confidential military character were begun in 1917 at the request of the War and Navy Departments, and a special fund for military investigations being available, a considerable number of scientific experts were added to the Bureau's staff to carry on this work.

Military problems in connection with radio communication immediately received special attention, and steps were taken to make the radio laboratory more efficient for coöperation with the military departments of the government. An urgent deficiency appropriation act of October 6, 1917 (40 Stat. L., 375), added $40,000 to the amount already appropriated for the radio laboratory.

In coöperation with manufacturers and users of radium luminous preparations the Bureau began the investigation of these preparations and their adaptability for illumination of dials and other instruments employed in aviation and for other military uses. Conferences concerning the military use of these materials were had with members of the Aviation Corps and the French Scientific Commission, and preliminary reports were furnished on request to the National Advisory Committee for Aeronautics and to the Signal Corps.

The Bureau, early in the war, completed and turned over to the Ordnance Department of the army a number of 70-inch standard bars to be used for standardization purposes at the arsenals. By having these uniform standards, the interchangeability of the parts of the great rifles for coast defense could be effected, and it became possible for the parts of a gun to be made at several arsenals to be assembled at one, thus reducing the time and cost of manufacture.

The making of shells and similar articles on an absolutely interchangeable basis required the use of a great number of accurate gauges. The Bureau took a leading part in assisting the military authorities by testing large numbers of gauges, and in manufacturing gauge blocks, an industry previously confined entirely to one firm in Europe. The process employed in this manufacture has since been perfected and adopted by one of the leading makers of precision tools in the United States.

The Bureau coöperated with the military authorities in the standardization of military supplies, the success of which work opened up the subject of standardization on a much broader scale, especially in connection with electrical supplies and equipment, and a most thorough standardization was completed and embodied in the catalogues of military supplies.

An acute shortage that was keenly felt at the outbreak of the war was that of optical glass and optical instruments. As these had been largely obtained from Europe, especially from Germany, the foreign supply was practically cut off. The need for binoculars and field glasses for military use was so great that an appeal had to be made to private owners throughout the country for the loan of such instruments. The Bureau for a number of years had been carrying on experimental work in its own shops with the view of assisting in the manufacture of high-grade optical glass in this country. The information gained in regard to the pots used and materials involved, the technique of the furnace, the molding, annealing, testing, and inspection of glass, was given freely to the manufacturers of optical glass who were endeavoring to supply the large and sudden demand for military optical instruments. The Bureau also coöperated with the military and naval authorities and with manufacturers in the specification, testing, and standardizing of such instruments. This experimental work in optical glass has been continued to the present time.

An elaborate investigation conducted by the Bureau on the use of ultraviolet light for signaling purposes resulted in the development of a suitable glass through which to view such light, which is invisible to the naked eye, when used for military signaling. Panchromatic plates for airplane cameras were also developed for use in rapid photography.

As aircraft played a most important part in the war, the Bureau made a thorough study of the aeronautic situation. Its work included tests, in an altitude laboratory, on various aeronautic engines to determine the variation of horsepower with altitude, compression ratio, and air temperature; the value of supercharging devices designed to enable airplanes to attain higher altitudes; the comparative value of various aviation fuels; the preparation of specifications for special aviation gasoline; and the relative merits of different carburetors, radiators, and other apparatus. Investigations were made of airplane ignition systems; of the strength of materials used in airplane construction; and of devices for synchronizing machine-gun fire with airplane propellers. Tests were made of all kinds of aeronautic instruments, and certain special devices were developed; also tests of aerofoils and model airplanes, lubricating oils, and airplane wings; studies of self-luminous materials for use on dials of aeronautic instruments; routine tests and development of special varnishes for airplanes; and other researches and tests for the determination of important fundamental data needed in aeronautics.

This work was done for the use of and in coöperation with the air services of the army and navy, the National Advisory Committee for Aeronautics, the Bureau of Aircraft Production, and manufacturers of airplanes. Activities in this field have resulted in great permanent value and have become part of the regular functions of the Bureau.

The Bureau conducted a three weeks' course in aeronautic instruments for aviators, covering the theory and testing of aeronautic instruments. Data and illustrative materials for similar courses were furnished for the use of the army.

The Bureau acquired, before and during the war, one of the most complete collections of aeronautic instruments in the world, including samples of practically every kind of airplane instrument made in this country and such kinds made in foreign countries as were obtainable. It was, therefore, the best equipped organization in the country for furnishing information concerning aeronautic instruments.

The war work in the field of metallurgy included a complete investigation of aluminum alloys for use in the construction of air-craft engines, government bronzes, development of special steels, investigation and development of satisfactory aluminum solders, the preparation of specifications for bearing metals, and routine testing of gun steel and similar work. In this activity the

Bureau coöperated with the army and navy, the National Advisory Committee for Aeronautics, and other military bureaus.

The Bureau's war work involving electrical principles covered many subjects, such as the location of enemy batteries by means of sound-recording mechanisms, time studies of gun firing, variation of gun pressures, ejection-velocity studies by recoil meters, the development of kinemometers to measure the jump and whip of a gun on firing, the measurement of projectile velocities inside the gun, and scientific studies of the gun blast. Special investigations were conducted of battleship turret firing, and the firing circuits were greatly improved; tests were made of electric trucks and tractors, of electric lamps and other electric appliances; studies were carried on concerning the possibilities of improving cable insulation; studies concerning fire-control on battleships; technical methods of protecting ships against mines were studied; measurements were made of speed of bullets fired by centrifugal guns; radio apparatus and numerous new devices and methods of measurement were applied to artillery, and other war problems involving the use of electricity were developed. Among these was a method for measuring the velocity of flame propagation in the cylinders of internal combustion engines. A special manual for radio operators was prepared during this period.

The war work of the Bureau in the field of chemistry consisted chiefly of the analysis of materials required by the various branches of the military service, and in the supplying of information for use in determining the most suitable materials for various military needs. It included tests of materials for the construction of gas masks, and studies of the composition and effects of poison gases; the development and the preparation of specifications for special paints, enamels, and varnishes, and the preparation of specifications for prepared roofing for temporary war buildings. Owing to the shortage of suitable dyes for use in the manufacture of army uniforms, the Bureau made an investigation of textile dyes, developed satisfactory methods for testing materials for army uniforms as to dye fastness and other chemical properties, and aided in the preparation of suitable specifications to be used in the purchase of dyes.

In other fields of war activity, one of the appropriations made, in addition to allotments from the National Security and Defense

Fund, was an item of $50,000 in the urgent deficiency appropriation act of March 28, 1918 (40 Stat. L., 496), "to enable the Bureau of Standards to make investigations urgently needed by public utility companies in order to improve their efficiency and adjust their methods of operation to meet the changed economic conditions incident to the war, and to aid state and municipal administrative officers and the management of publicly owned utilities in adjusting standards of service when necessary."

Among the military devices developed by the Bureau either solely by its own staff or in coöperation with experts of the army and navy and of manufacturers were: Sounds-ranging devices; the application of the radio compass to both air and water navigation; instruments for the navigation of air craft; a hydrogen detector for submarines; optical instruments for observation, range finding, and navigation; improved designs of rifles and machine guns; a special carburetor for air-craft engines; and a high-speed gas-engine indicator.

In the conduct of its war activities the Bureau coöperated with such civil organizations as the Aircraft Board, the Emergency Fleet Corporation, the National Research Council, the War Industries Board, the National Advisory Committee for Aeronautics, the United States Railroad Administration, the Bureau of War Risk Insurance, the American Red Cross and others. Among the army organizations that came into closest coöperation with the Bureau were the Air Service; Coast Artillery Corps; Construction Division, Engineer Corps; Field Medical Supply Depot; Inventions Section, General Staff; Motor Transport Corps; Ordnance Department; the Purchase, Storage, and Traffic Division; the Quartermaster Corps; and the Signal Corps; and of the navy, the Bureau of Construction and Repair; Bureau of Ordnance; Bureau of Steam Engineering; Bureau of Yards and Docks; Hydrographic Office; Office of Naval Intelligence; and various navy yards and naval bases.

During the war much attention was given to the study of essential materials, such as metals, cement, lime, paper, textiles, rubber, leather, oils, clay products, etc., the work being paid for either out of general or special appropriations or the National Security and Defense Fund. Thus, an act of July 3, 1918 (40 Stat. L., 808), appropriated $10,000 for the Bureau "To investigate textiles, paper, leather, and rubber in order to develop standards of quality and methods of measurement," an appropriation which has been repeated each subsequent year and finally increased to $27,000. As a result of the paper investigation the Bureau demonstrated that good paper can be made from linters, of which about 700,000 bales per year are available for this purpose.

The necessity for increasing as much as possible the American output of sugar brought up many new problems which required the earliest possible solution, and the Bureau rendered much assistance of a technical character to this industry. To enable the Bureau to begin this work, the act of July 3, 1918, appropriated $20,000 " for the standardization and design of sugar testing apparatus; the development of technical specifications for the various grades of sugars with particular reference to urgent problems made pressing by war conditions, especially involving the standardization and manufacture of sugars; for the study of the technical problems incidental to the collection of revenue on sugar and to determine the fundamental scientific constants of sugar and other substances." This work also became a regular function of the Bureau, the appropriation for it having been repeated each year and increased to $38,160 for the fiscal year 1926.

A small appropriation of $4000, made by the same act " for purchase, preparation, analysis and distribution of standard materials to be used in checking chemical analysis in the testing of physical measuring apparatus," has also been repeated each year and finally increased to $10,000.

An act of June 12, 1917 (40 Stat. L., 167), making appropriation for the fiscal year 1918, provided for " developing by the Bureau of Fisheries in coöperation with the Bureau of Standards, new aquatic sources of supply of leather . . . , to be immediately available, $10,000." The Bureau of Standards coöperated with the Bureau of Fisheries by furnishing a technically trained tanner who made experiments in the tanning of fish skins, which developed the fact that shark skins could be tanned into upper leather for shoes. Three additional annual appropriations were subsequently made for this work.

Among the other important new activities of the Bureau during the war period but not directly connected with the war, were the preparation and publication of a circular (No. 6) containing a comprehensive treatment of the various electrical standards and the standards by means of which the units are maintained, including among other data, a history of the units and the evolution of the definitions upon which the laws on electrical standards are based, and a statement of the present status of the fundamental electrical standards and of the laws on electrical units in various countries of the world.

After a joint conference of representatives of the government, the American Society for Testing Materials, and the American Society of Civil Engineers, the Bureau prepared and issued, as Circular 33, January 18, 1917, revised standard specifications for Portland cement.

The Bureau in 1917 coöperated with the United States Employees' Compensation Commission and representatives of the War and Navy departments in the preparation of a set of definite safety standards for application in the several establishments.

An activity of permanent value to the coal mining industry was provided for in an appropriation of $15,000 made March 28, 1918 (40 Stat. L., 495), "for investigating the condition and methods of use of scales and mine cars used for weighing and measuring coal dug by miners, for the purpose of determining wages due, and of conditions affecting the accuracy of the weighing and measuring of coal at the mines." The Bureau immediately undertook a nation-wide investigation which disclosed many unsatisfactory conditions such as improper installation of scales and faulty methods of weighing, and produced evidence which resulted in the finding of indictments and the imposition of fines for law violations. An appropriation of $15,000 for this work has been made each year since that time.

A standard screen scale for testing sieves, adopted by a conference of representatives of various technical societies, government bureaus, and private firms interested in sieving tests of materials was issued by the Bureau, together with specifications and tolerances under which the Bureau will test and certify sieves of this character. The scale is intended to cover practically all materials upon which fineness tests are made, and its adoption will unify the results of sieve tests and reduce the varieties of sieves required for such work.

The construction of a large four-story industrial laboratory building was begun in 1918, to house the work along the lines of structural materials and industrial research and related subjects. This was made possible by the allotment, from the National Security and Defense Fund, during the fiscal year ending 1918, of $893,500, of which $883,840.80 was expended.

Other allotments made from the National Security and Defense Fund, in 1918 and 1919, the total of which, including the above, amounted to $2,137,095.03, were for an altitude laboratory, armament of fortifications, navy aviation, completing laboratories, metallurgical work, military researches, new building, power plant equipment, production of fabrics, production of optical glass, Robert's coke oven, and thermite investigation.

The act of July 18, 1918 (40 Stat. L., 912), provided for the appointment of a commission of nine members under the chairmanship of the Director of the Bureau of Standards "to ascertain and establish standards for screw threads," the membership to consist of appointees of the Secretaries of War, the Navy, and Commerce, the American Society of Mechanical Engineers, and the Society of Automotive Engineers. The act provided that the Commission should terminate at the end of six months from the date of its appointment, but Congress subsequently extended its term to March 21, 1927. A "progress report"[35] of its work was approved June 19, 1920, and issued January 4, 1921, the Commission having devoted its attention "to the standardization of only those threads, sizes, types and systems which are of paramount importance by reason of their extensive use and utility." According to a statement in the report, "The advances made by the Commission up to date will reduce the variety of screw threads in general use, facilitate manufacture in case of war, make the best use of labor in our industries in time of peace, increase the safety of travel by rail, steamship, and aeroplane, and in general will increase the dependability of all mechanisms." The report is of fundamental interest and value in mechanical engineering.

Post War Activities. The transition from war to peace brought many special problems of reconstruction work to the Bureau of

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[35] Progress report of the National Screw Thread Commission, etc., Bureau of Standards, Miscellaneous Publication No. 42.

Standards, as it did to other government services. Certain military researches were continued because of their permanent value to the army and navy. Some researches and tests for other government departments and for private organizations undertaken on account of the war emergency were continued, because their value to science and industry in peace time had been demonstrated. Still other pre-war activities, deferred during the war, were resumed after the armistice, and various new programs of industrial and scientific research were taken up.

In order to enable the Bureau to give special attention to the readjustment of industrial research work, an act of March 1, 1919 (40 Stat. L., 1261), appropriated $50,000 to be expended "for technical investigations in coöperation with industries upon fundamental problems involved in industrial development following the war, with a view to assisting in the permanent establishment of new American industries developed during the war." This appropriation has been repeated for each subsequent year and has been very materially increased, the amount appropriated for the fiscal year 1926 being $174,120.

Another appropriation of $100,000 was made in the same act for equipment.

Among the most important lessons learnt during the war was the fact that standardization is a first essential to efficient warfare, as it is to efficient industry in time of peace. Technical experts, societies, and the industries have realized the supreme importance of standardization, and in nearly all fields of technical activity standardization committees have been organized, on which the Bureau of Standards is presented and with which it coöperates.

For the government, the Bureau acts as scientific advisor on the subject of standard specifications, notably the War Department and the General Supply Committee.

On January 15, 1919, a safety conference was held at the Bureau for the purpose of arranging for more complete coöperation on the part of state authorities and others interested in safety work, and of insuring coördination of efforts for accident prevention. The conference was attended by more than one hundred representatives of different organizations concerned with safety standards.

On December 8, following, another conference on industrial safety codes held at the Bureau, was attended by over one hundred representatives of interested organizations in many parts of the country. This conference voted in favor of having safety codes prepared under the auspices of the American Engineering Standards Committee, and provided for the formation of a joint safety code committee to prepare a list of codes already in existence or urgently needed, and to recommend sponsors for preparing and revising these codes. Such a committee was formed at the time and has since been succeeded by theSafety Code Correlating Committee, upon which the Bureau is represented.

Recommendations have been made by this committee to the American Engineering Standards Committee for a large number of safety codes, most of which have been approved by that body. Seven codes were recommended for sponsorship by the Bureau, including the national safety codes for electricity, gas, head and eye protection, fire, lighting, logging and saw mill operations, and aeronautics. The Bureau at that time had already prepared the Electrical Safety Code, National Elevator Safety Code, National Code for Safeguarding Machines and Machine Drives, National Code for the Protection of Head and Eyes of Industrial Workers, and National Code for Safeguarding Remote Control Apparatus.

During the fiscal year 1919 the Bureau conducted courses of instruction in measurement and in the use of the Bureau's special gauge-testing apparatus and methods in field work. These courses were attended by government supervisors and inspectors from both War and Navy Departments and from manufacturers of munitions and military materials.

The Bureau undertook during this year for the Air Mail Service, the development of a method by which aviators may land in fog. The system which was successfully developed involves the use of automatic radio signaling equipment on the landing field in combination with suitably designed direction finders on the airplane. The Bureau also developed and applied a successful submarine radio system, making possible signaling from a submerged submarine for a distance of 12 miles and the receiving of signals transmitted thousands of miles as when received in the air.

The Bureau in 1919 prepared and published, for the use of public utilities organizations, standards for street lighting and for telephone services.

The new industrial laboratory was completed in the spring of 1919. It affords unusual facilities, probably unexcelled in any laboratory, including well developed and equipped laboratories of the scientific divisions of chemistry, heat, light, electricity. This laboratory also houses the staff and equipment of the branch laboratory formerly conducted at Pittsburgh. A dynamometer building was also equipped and occupied, and researches in power plants for airplanes and other motor craft were undertaken in the new quarters. The new building is equipped with an altitude laboratory for testing engine performances, consisting of two vacuum rooms for simulating the conditions at high altitudes.

Special liberality was shown by Congress in its appropriations for the Bureau for the fiscal year ending 1920, $515,000 being appropriated in regular and deficiency appropriation acts for seven new investigations. Of these, five, for metallurgical research, $25,000; for high temperature investigation, $10,000; for sound investigation, $5000; for standardization of equipment $50,000; and for industrial research $300,000, were repeated for each subsequent year, two being very materially increased. The exact nature of these appropriations is shown in the text of the current appropriation act in Appendix 4.

The other new appropriations for activities, made for 1920, were for testing government materials, $100,000, and for industrial safety standards, $25,000, both of which were made in the deficiency appropriation act of November 4, 1919 (41 Stat. L., 340), and provided as follows:

> For specification, testing, and inspection of materials and equipment purchased by the government departments to determinine suitability for the specific uses involved . . . $100,000;
>
> To investigate conditions of personal hazard in electrical, industrial, and mercantile establishments and other places where apparatus and machinery are used or hazardous materials are handled; to formulate safety standards covering construction, installation, and operation of electrical and mechanical apparatus and machinery, and the handling of materials; to prepare national safety codes suitable for general application and for adoption and enforcement by Federal, State and Municipal bodies; and to coöperate

with engineering and industrial organizations in the development and revision of such codes and with administrative bodies in the introduction and interpretation of the codes . . . $25,000.

The same act (p. 341) made an appropriation of $15,000 "for the purchase of platinum and other rare metals required for use in the experimental work of the Bureau," and $20,000 for the completion of a retaining wall along the south side of the new industrial laboratory. The legislative appropriation act of March 1, 1919, for 1920 (40 Stat. L., 1261), made a provision of $100,000 "for moving and installation of present equipment, and the purchase of new equipment."

The appropriation act of May 20, 1920 (41 Stat. L., 683), had a provision, which has been repeated in appropriation acts for each subsequent year, providing that "the head of any department or independent establishment of the government having funds available for scientific investigations and requiring coöperative work by the Bureau of Standards on scientific investigations within the scope of the functions of that Bureau and which it is unable to perform within the limits of its appropriations, may, with the approval of the Secretary of Commerce, transfer to the Bureau of Standards such sums as may be necessary to carry on such investigations." This provision specifically authorizes reimbursements to the Bureau from other government agencies for which services have been rendered.

An act of June 5, 1920 (41 Stat. L., 934), appropriated $47,272 for the purchase of additional land adjoining the site of the Bureau of Standards. The purchase was made soon after its authorization.

The same act (p. 935) authorized and directed the Bureau "to make an investigation as to the standard, quality, and cost of production and distribution of gas furnished the government and private consumers in the District of Columbia," but made no special appropriation for this activity.

The Bureau in 1921 published the results of an extensive fire test of building columns, made in coöperation with professional interests.[36] These results constitute a distinct contribution to the effectiveness of building design from the viewpoint of fire hazard.

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[36] Fire tests of building columns, 1921, 375 Bureau of Standards Technologic Papers, 184.

In coöperation with the Signal Corps, a special direction finder has been developed for use on motor tractors, which will enable one of these machines to locate its position on land by reference to signals sent out from definite stations in the same way that vessels can now do on the water.

The Bureau, in 1921, in coöperation with the Bureau of the Mint made an elaborate study of the spectra of various alloys of gold, the results of which may revolutionize the methods of gold analysis in use by the Mint.

In order to keep in close touch with the latest development in aeronautic instruments in foreign countries, a representative of the Bureau was detailed in 1921 to make observations and studies in the leading European countries, particularly England, France, Germany, and Italy. During the summer of 1921 a representative of the Bureau served as a member of the United States delegation to the International Radio Conference and at a meeting of the International Union of Scientific Radio Telegraph, both at Paris.

In 1921 a new Division of Building and Housing was organized in the Bureau for the purpose of dealing with the problems of standardizing building materials throughout the country, with the view of cheapening and improving the construction of houses; formulating building and plumbing codes; and otherwise dealing with the housing problem. This new activity was inaugurated following the enactment of a provision of an act of June 16, 1921 (42 Stat. L., 47), transferring $250,000 of the appropriation of $1,000,000 for the Bureau of the Census for the fiscal year ending 1922, to the Bureau of Standards, of which $50,000 was for the continuation of the investigation of structural materials with the provision "that as much of this sum as necessary shall be used to collect and disseminate such scientific, practical, and statistical information as may be procured, showing or tending to show improved methods in building, planning, and construction, standardization, and adaptability of structural units, including farm buildings, building materials, and codes, economy in the manufacture and utilization of building materials and supplies, and such other matters as may tend to encourage, improve and cheapen construction and housing."

Of the remainder of this transferred appropriation, the act directed that $100,000 was to be devoted to the industrial research investigation, and $100,000 to the work of testing, etc., for the standardization of equipment.

In January, 1922, a Division of Simplified Practice was organized in the Bureau to coöperate with American industries in furthering a nation-wide program for eliminating waste in commerce and industry by reducing the number of sizes and types of standard products.

One of the immediate activities of this division was the bringing about of a survey of the paving-brick industry by the National Paving Brick Manufacturers' Association, in coöperation with the Bureau, resulting in a meeting of thirty representatives of brickmaking organizations at which, by mutual consent, the sizes and styles of paving brick were reduced from sixty-six to eleven, and later to seven. This work has been very materially expanded.

The Bureau, by an act of March 28, 1922 (42 Stat. L., 478), received a new appropriation of $10,000 which has been repeated in subsequent acts and increased to $10,680, " for an investigation of radio-active substances, and the methods of their measurements and testing."

A new appropriation of $20,000 was made in an act of January 5, 1923 (42 Stat. L., 1110), for the study of ropes and cables. The next year a similar appropriation of $8000 was made, but was subsequently discontinued.

On January 1, 1923, Dr. Samuel W. Stratton, who had served continuously as Director of the Bureau of Standards since its creation in 1901, resigned in order to accept the presidency of the Massachusetts Institute of Technology. He was succeeded by Dr. George K. Burgess, physicist, who was promoted from the position of Chief of the Division of Metallurgy.

An appropriation of $25,000 for " Investigation of automotive engines " was made in an act of May 28, 1924 (43 Stat. L., 233), and was repeated the following year. This activity had previously been carried on out of funds transferred from other appropriations.

An act was approved February 19, 1925 (43 Stat. L., 951), authorizing the Secretary of Commerce to acquire additional land for the site of the Bureau, and on March 4, 1925 (43 Stat. L., 1313, 1328), an appropriation of $173,117 was made for its purchase.

CHAPTER II

ACTIVITIES

Functions. The functions of the Bureau of Standards as defined by the act of March 3, 1901 (31 Stat. L., 1449), consist of "the custody of the standards; the comparison of the standards used in scientific investigations, engineering, manufacturing, commerce, and educational institutions with the standards adopted or recognized by the government; the construction, when necessary, of standards, their multiples and subdivisions; the testing and calibration of standard measuring apparatus; the solution of problems which arise in connection with standards; the determination of physical constants and the properties of materials, when such data are of great importance to scientific or manufacturing interests and are not to be obtained of sufficient accuracy elsewhere." Since the enactment of this law, Congress has made from time to time many appropriations for specific activities, some of which were of a temporary and others are of a permanent character. There are also some functions which were inherited from the Office of Standard Weights and Measures that are not specifically mentioned in the organic act.

This act provides that "The Bureau shall exercise its functions for the Government of the United States; for any state or municipal government within the United States; or for any scientific society, educational institution, firm or corporation, or individual within the United States engaged in manufacturing or other pursuits requiring the use of standards or standard measuring instruments."

With regard to charges for these services, the act provides that "for all comparisons, calibrations, tests, or investigations, except those performed for the Government of the United States or state governments within the United States, a reasonable fee shall be charged, according to a schedule submitted by the director and approved by the Secretary of Commerce."

It is the policy of the Bureau, to discourage the sending to the Bureau of tests that can be performed by private laboratories. Applicants for tests of this character are advised to have such work done in a consulting laboratory or elsewhere, and a list of such laboratories is furnished them when possible.

In the case of instruments there are, in most instances, no other agencies which are qualified to make such tests, and the Bureau helps the American manufacturers in testing and keeping up the quality and raising the performance of their instruments by testing them, determining their actual performance, and advising the makers as to what should be done to improve them. A fundamental reason for the establishment of the Bureau of Standards was to make the American instrument manufacturer independent of the foreign market, and it may be said that the American instrument manufacturing industry is in a measure an outcome of the activities of the Bureau of Standards. While before the war 85 per cent of the instruments bought in this country were imported, at present about 90 per cent are of American make. The Bureau of Standards, however, is unable to meet the demands for tests of instruments for dealers and users, because adequate funds for this work are not available.

In his statement before the subcommittee of the House Committee on Appropriations[1] February 12, 1924, the Director said:

> The problems taken up are not of the type that can best be solved in the industrial plant, but are in all cases of fundamental importance to a given industry as a whole and are concerned mainly with standardization, determining physical and chemical constants, characteristics, and utilization of materials in the development of processes, the elimination of waste, new methods of measurement, and participation in those problems in which the Government can most advantageously intervene constructively as in cases where producers and consumers can be brought together.

In addition to the general directions of the organic act, the Bureau receives each year special directions in the form of appropriations for particular undertakings. Thus, for the fiscal year ending June 30, 1926, Congress made such specific appropriations for testing structural materials; investigation of fire-resisting properties of building materials; investigation of public utility standards; testing miscellaneous materials; investigation and standardization of methods and instruments employed in radio communication; color standardization; investigation of clay products; standardizing mechanical appliances; investigation of optical glass; investigation of textiles, paper, leather, and rubber; sugar standardization; gauge standardization; investigation of mine scales and cars; metallurgical research; high temperature investigations; sound investigation; industrial research, that is, technical investigation in coöperation with the industries; testing railroad track and other scales; standardization of equipment; purchase, preparation, analysis, and distribution of standard materials; investigation of radioactive substances; and investigation of automotive engines; The text of the act making these appropriations is given in Appendix 4.

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[1] Department of Commerce Appropriation Bill, 1925. Hearing before Subcommittee of House Committee on Appropriations, etc. 68 Cong. 1 sess., p. 217, 1924.

Standardization as defined by the Bureau of Standards is "the fixing in measurable terms, the optimum magnitudes of the separate pertinent factors essential to a given service." The standards which the Bureau is authorized to deal with have been designated as standards of measurement, standard values of constants, standards of quality, standards of mechanical performance, and standards of practice.

The Bureau's predecessor, the Office of Standard Weights and Measures, originally dealt only with standards of weights and measures. Then came the task of establishing temperature standards for the country. These tasks were followed in succession by the establishment of electrical standards, photometric and other optical standards, standards for a large variety of materials, such as metal products, cement, paper, leather, and, in fact, of nearly everything of technical and industrial interest that was bought on quality specification. This work of standardization is largely accomplished through the coöperation of experts of the Bureau with the engineering and industrial organizations of the country, resulting in the formulation of specifications which define the standard materials or objects.

It is not the policy of the Bureau to adopt arbitrarily technical standards used in any particular branch of manufacture, but when such interests agree as to the best standards in any particular case, it undertakes to determine whether the articles submitted conform to the standards so agreed upon. When steps are thus taken by manufacturers to adopt technical standards, the Bureau is prepared to give advice and to assist in every way.

Some of the functions of the Bureau of Standards appear to be similar to those of other branches of the national government, but care has been taken to avoid overlapping of activities. Thus, the Bureau of Standards and some of the bureaus of the Department of Agriculture do similar investigational work, but the latter deal primarily with agriculture and products of the soil, a field which the Bureau of Standards does not invade. Both the Bureau of Standards and the Bureau of Mines of the Department of Commerce give much attention to work in metallurgy, but the latter is primarily interested in mining operations and in what is called "process metallurgy," that is, smelting of metals from the ore; while the Bureau of Standards is interested in carrying the material into the finished form and in studying the properties of the finished material.

Activities. The activities of the Bureau of Standards have varied from year to year, being carried on either in compliance with special statutory direction or to meet the demands of science and industry under the provisions of the organic act. As the individual activities each year are numbered by the thousands, they cannot all be described or even listed here, but an endeavor is made to give a fairly accurate idea of the general nature and scope of the Bureau's work.[2]

As carried on during the fiscal year 1925, the activities of the Bureau may be grouped under the following general heads: weights and measures work; electrical work; gas engineering; safety engineering; study of radioactivity; X-ray measurement; atomic tests of measurements; heat and power measurement and research; investigation of fire-resisting properties of building materials; study of automotive power plants, fuels and lubricants; work in optics; work in chemistry; work in mechanics; sound measurement; study of structural and engineering materials; study of miscellaneous materials; work in metallurgy; work in ceramics; work in glass; standardization of equipment; and building and housing service. The Bureau also conducts, outside of office hours, classes for the instruction of its personnel, but this instruction is not one of its prescribed functions.

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[2] The individual activities of the Bureau each year are to some extent described in the annual reports of the Director of the Bureau of Standards.

By its close coöperation with other services of the national government, with state and local governments, and with various scientific, technical, and industrial organizations; by its participation in national and international conferences on standardization and other scientific conferences in many fields; by its collaboration with scientists and experts of such organizations both here and abroad in making tests, comparisons and researches; by the personal studies and observations undertaken by members of its staff concerning methods and results in this and foreign countries; and by affording opportunities for self-advancement and encouraging an *esprit de corps* among its employees; the Bureau of Standards manages to accomplish a great amount of valuable scientific and technical work which is out of all proportion to the expense incurred therefor.

The service which the Bureau renders to the national government is of the greatest importance. In its work on specifications, testing, scientific and technical researches, standardization, simplification, and housing, it acts as a great consulting laboratory for the other branches of the government and is instrumental in effecting great savings in government purchases and services.

Weights and Measures Work. The activities of the Bureau concerning weights and measures consist of research and measurements involving the fundamental units of length, mass, and time, and the derived or secondary units, such as area, volume, density, and pressure; the preparation of tolerances for use in connection with standardization of weighing and measuring apparatus, gauges, and screw threads; coöperation with states in the preparation and enforcement of weights and measures legislation, in the administration of weights and measures departments, and by testing, and calibrating standards for their use; the design, improvement, inspection, and method of test of weighing and measuring apparatus, both precise and commercial; carrying out researches designed to result in more accurate knowledge of physical constants; improvement in engineering practice; and the drafting of regulations for the enforcement of certain weights and measures laws.

This group of activities is carried on in part under the general salary and equipment appropriations, and in part under special annual appropriations for "testing railroad track and other scales," for "investigation of mine scales and cars," and for "gauge standardization."

Our present fundamental standards of length and mass in the United States are the meter and kilogram, respectively, which were sent to this country from France in 1889 by the International Bureau of Weights and Measures located at Sèvres, near Paris.[3]

An act of July 28, 1866 (14 Stat. L., 339), makes it lawful throughout the United States to employ the weights and measures of the metric system and defines the relations which are to be recognized in the construction of contracts and in all legal proceedings between the weights and measures of the metric system and the system of weights and measures in common use in this country. Our standard yard, pound, etc., are derived from the fundamental standards mentioned above. The working standards which the Bureau of Standards uses in making comparisons of weights and measures submitted for test are compared as often as is necessary with the fundamental standards of the country, and thus our measurements are in reality referred back to the standards deposited in the International Bureau, of which our fundamental standards are copies.

The Bureau of Standards calibrates the standards of weights and measures of the states of the Union whenever requested to do so by the state authorities.

Through its standardization of weights and measures, the Bureau performs a function which is of fundamental importance to the whole industrial fabric of the country. It brings about accuracy in industry by providing uniform and correct measures; aids commerce in the standardization of the sizes of containers and products; promotes justice in daily trade through encouragement of systematic inspection and regulation; and facilitates precision in scientific and technologic research through calibration of apparatus and instruments involved.

In order that the greatest degree of perfection in the methods and equipment of this branch of the Bureau's work may be obtained, officers of the Bureau at times visit standardizing laboratories in foreign countries for observation and study. There are specific provisions made in the appropriation acts to cover this country's share of the expense of maintenance of the International Bureau of Weights and Measures, and the expenses of a delegate to the general conferences of that organization which are held once each six years.[4]

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[3] See page 23.

The Bureau of Standards is in constant communication with other national laboratories in England, Germany, and other foreign countries, with which it intercompares standards of weights and measures, of temperature, of electrical instruments, photometric standards, etc. Such intercomparisons are of the greatest importance, especially on account of the international interchange of commodities. While all the participating countries, including the United States and Great Britain, have received copies of the international meter, there is lack of agreement between the two countries mentioned as to the exact relation between the meter and the yard. While the difference is very small, it is nevertheless troublesome because it must be taken into account in all high precision work engaged in by persons of the two countries. Efforts are being made to effect an agreement between the United States and Great Britain on the exact ratio of the yard to the meter.

At a recent meeting of the International Conference of Weights and Measures a method of coöperation among the several national laboratories and the International Bureau was established so that the latter will be a clearing house or exchange for these laboratories.

The Bureau of Standards also renders a most valuable service to the entire country by its activities in connection with the annual conferences on weights and measures, which were begun at the instance of the Bureau and have been held annually for seventeen years. At these meetings the weights and measures officials of the states and municipalities throughout the country are brought together in conference. This has resulted in better and more uniform weights and measures legislation, better methods of regulation and enforcement, and better equipment for such work.

[4] See page 254.

The weights and measures work of the Bureau may be described under nine groups; namely, activities relating to length, mass, time, capacity and density, gas measuring instruments, thermal expansivity of solids, investigations and tests of commercial scales and related work, gauge standardization, and administration of weights and measures laws.

Length. All length measurements of the United States and nearly all other governments are based upon an international meter, which is defined as "the distance, at the temperature of melting ice, between two fine lines ruled on a bar of platinum-iridium preserved at the International Bureau."[5] Accurate copies or prototypes of this bar have been made and distributed among most of the governments of the world. The Prototype Meter No. 27, the copy in the custody of the Bureau of Standards, is the American standard.

The activities of the Bureau with regard to measures of length consist of preserving and comparing the national prototype meter and its copies; developing methods and apparatus for length measurement; preparing specifications for instruments and materials requiring linear dimensions of a definite and stated accuracy; making tests of instruments and materials to determine conformity to specifications; making measurements of length of a miscellaneous and varied character, including study of conditions of use of apparatus and precision and nature of tests required; obtaining, compiling, and distributing to manufacturers and others, information regarding methods of length measurement; and comparing state, municipal, and other standards of length with the national standards. Closely associated with this work is the measurement of angle, a phase of the Bureau's work of interest to geodesists and surveyors.

In 1923 the national prototype meter, the primary standard of length of the United States, was brought back from the International Bureau, where it had been taken two years before for comparison with the international standards. It was found that our national standard of length has remained constant within the errors of the most precise measurements since its original comparison in 1889. From this standard are derived all other standards of length used in the United States, with their subdivisions and multiples, including the yard, using the relation between the yard and the meter (1 yard $= \frac{3600}{3937}$ meter) contained in the act of 1866.

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[5] The National Bureau of Standards, 1911, p. 7.

Researches are being made by the Bureau of Standards concerning the construction and maintenance of standards of different types and their proper use and care. Studies have recently been made of the methods of precision length measurement employed in Europe, and of the methods of graduating invar tapes and an investigation has been made of the character of surfaces and defining lines on yard and meter bars.

Length measures are standardized under definite conditions of temperature and manner of support. The length tests made by the Bureau in recent years include primary standards for states, educational institutions, and manufacturers, invar base line tapes, steel tapes, level rods, woven metal wire sieves for cement, sand, etc., sieve cloth, and blood counting chambers.

Considerable time is being devoted to the testing of metallic sieves. Many cement sieves are tested since all cement purchased by the national government, as well as by many construction engineers and builders, must conform to certain specifications, which requirement necessitates among other tests the sifting of samples through testing sieves certified by the Bureau of Standards. Hundreds of such sieves having various apertures are submitted annually to the Bureau for certification according to the specifications of the United States Standard Sieve Series. To facilitate the accurate testing of sieves, a sieve-testing apparatus has been developed whereby a projection method is used for magnifying the sieves instead of measuring directly by means of a micrometer microscope. Fees have been established for this work.

Another series of tests, in which the number of articles submitted each year runs far up into the hundreds consists of blood counting chambers (hæmacytometers) and cover-glasses for the same. As these are used in microscopic blood examinations the glass must be free from bubbles or streaks, and the dimensions of the chamber must conform to certain specifications which require microscopic tests; likewise the cover glasses must be plane on one side within 0.002 millimeters. These tests are made mainly for manufacturers and dealers who supply the tested apparatus to their customers. A fixed charge is made for these tests and certifications.

The invar tapes used by the Coast and Geodetic Survey are calibrated and tested by the Bureau of Standards, which also tests other measuring instruments used by the Survey and by other government organizations. Similar tests are also made for private individuals and organizations, for which services the Bureau has a scale of fixed charges.

The Bureau maintains a fairly complete bibliography in card-index form, of primary sources of information on precision length measurements and on miscellaneous publications relating to metrology.

Mass. The standards of mass or weight in the United States are based upon a certain cylinder of platinum-iridium, known as the international kilogram, preserved at the International Bureau of Weights and Measures. From this, kilogram copies have been made, having the same mass, material, and form, and distributed among the various nations. The copies of the United States, which are in the custody of the Bureau of Standards are known as Nos. 4 and 20, the latter being the primary standard of mass. From the kilogram, all other units of mass or weight are derived in the United States, by applying the relation between the kilogram and the customary units, one pound, avoirdupois = 0.4535924277 kilogram.

The activities with regard to measure of mass consist of the custody of national standards of mass, testing standard weights and precise balances, and improving standards of mass and methods of weighing.

The weights tested range from those used by a state or city sealer in testing commercial weights and measures to those used by the scientist in the most precise work.

Researches in mass made by the Bureau cover a wide field affecting the maintenance, preservation, and proper use of standards of mass. The tests and determinations of mass made by engineers and chemists in which high accuracy must be used, annually involve millions of dollars.

Capacity and Density. Among the specific subjects covered in the researches of the Bureau are those dealing with materials suitable for weights of various grades of precision, and those concerning the investigation of protective coatings. In precision weighing it is important that the most precise information be obtained as to the buoyant force of the air and as to humidity effects. The determination of the volume of standards of mass has received careful attention at the Bureau. The measurement of capacity and density are so closely related that they may be considered as one group of activities. The standards of volume, such as the quart, gallon, bushel, etc., in customary use in the United States are defined as a certain number of cubic inches. These also are determined by their relation to the metric system, in which a kilogram of water at maximum density is the liter, the unit of volume. The relation between the metric and the customary measures as defined in the act of 1866 is 1 Liter=1 cubic decimeter=0.908 quarts dry measure=1.0567 quarts liquid measure.

The activities concerning capacity and density consist of testing capacity and density apparatus; designing, improving, and calibrating special volumetric apparatus; determining density and volume coefficients of liquids and preparing tables based thereon; and assistance to manufacturers of apparatus by conference and by correspondence.

Tests of volumetric apparatus are made by determining the amount of distilled water at a certain temperature that is contained or delivered by the vessel. Tests are made of thousands of glass measuring instruments, including flasks, pipettes, burettes, cylinders, and vessels of all kinds; and of cubic-foot standards used in standardizing gas and water meter provers.

The accurate testing of capacity measures and volumetric apparatus is becoming more and more important, in the sale of liquid commodities and in chemical analyses.

Accurate knowledge of the density of a unit volume of a substance is important in a large class of materials used in commerce, science, and the arts. In the case of liquids this can be obtained with a high degree of accuracy by the hydrometer, which usually consists of a glass bulb with a stem which, when placed in a liquid, sinks to a certain level, indicating the density of the liquid by graduation on the stem. The Bureau annually tests hundreds of hydrometers, and also makes accurate determinations of the densities of both solid and liquid materials of special interest and importance to the government, and to commerce, engineering, and science. Hydrometer tests are of special importance to the manufacturing chemistry and the petroleum industries.

Research on the density of denatured alcohol was recently conducted at the request of the Treasury Department to furnish information necessary for the proper supervision and control of the preparation and distribution of denatured alcohol for industrial purposes.

Time Testing and Research. The activities of time testing and research include the testing of watches, clocks, chronometers, drum chronographs and other time-measuring devices; carrying on researches on time-measuring devices, such as designing and experimenting with new types of time-measuring instruments, and correlating time-keeping qualities of watches with types and grades; serving on committees of and coöperating with organizations whose object is to improve the construction, test, use, and repair of time-measuring devices; and answering inquiries concerning time-measuring devices and related subjects, such as standard time belts, etc. Hundreds of clocks and watches are tested annually for the United States Shipping Board, the War Department, and for other governmental and private organizations. The Bureau has played an important part in attempts that are being made to produce in the United States ships' chronometers, which until recently have all been made abroad.

Within the past three years much attention has been given to the testing of watches repaired by applicants to the Horological Institute of America for certification as watchmakers. These watches, as well as others submitted to the Bureau, are tested for changes in rate caused by running in different positions, at different temperatures, etc. A fixed charge is made for this service.

A file of about ten thousand reference cards on sources of horological information is kept by the Bureau.

Gas-Measuring Instruments. An activity of the Bureau which enables it to render a most important direct service to the public is the testing and research work in connection with gas measuring instruments. In carrying on this work, the Bureau coöperates with citizens' committees whose functions are to specify standards for the construction, testing, and use of gas meters, and publishes works on gas measuring instruments and methods. Tests have been made in recent years of dry and wet meters, portable cubic-foot standards, spirometers, and other devices, and, in response to an urgent demand from another branch of the national government, some of the state governments, and several other organizations, an investigation is being carried on to develop some fundamental data on orifice meters for measuring large quantities of natural gas. A closely related problem, the test of large-volume gas meters, is also under way. This work is being carried on in Chicago in coöperation with a joint committee of the American Gas Association and the Natural Gas Association of America.

Thermal Expansivity of Solids. Under the head of thermal expansivity of solids are grouped such activities as the experimental determination of expansivity of solids and the dimensional variations incident to heat treatment, the ruling of scales and production of screws of high precision, and the giving of advice regarding the propriety of combining different materials in structures, apparatus, etc.

One of the activities in this field that has recently been taken up, is the investigation of dental inlay materials, involving the study of questions of plaster behavior, wax manipulation, and gold casting. In coöperation with the American Dental Association, studies are being made of the various instructions and formulas for dental work with regard to inlays, many of which were found to be defective. Measurements have been made of the expansions of various materials in setting, and it has been found that those made according to many formulas now in use give poor results. As a result of these studies, information is obtained which will permit commercial laboratories to install apparatus similar to that designed and used at the Bureau. It is believed that the information gained in this way will result in enormous savings to the general public. Tests and researches are being made concerning aluminum, lead-antimony and gold alloys, nickel steel, enamels, and glasses; the effects of lubrication upon moving parts of a dividing engine; and determinations of melting points, thermal expansion, and elasticity. Work is being done in designing and installing equipment for testing errors in screw threads, and apparatus for cutting screws to an accuracy of one-millionth of an inch, and for determinations of shrinkage, effects of pressure, porosity, etc., of certain materials; and designing, assembling, and testing bearings suitable for use in precision apparatus. The Bureau is engaged in producing screws of such accuracy and uniformity of pitch as to make it possible to construct a linear dividing engine for ruling scales and gratings of a higher accuracy than are now obtainable.

Investigating and Testing Commercial Scales. Under this head are included the activities of testing, and calibrating, railroad track, mine, and other heavy-capacity scales, and investigating conditions surrounding weighing of this character. The activities consist of calibration and maintenance of accuracy of master track scales; testing of railroad track and of mine scales; calibration of test cars and of heavy weights; development of weighing methods for heavy-capacity scales; development of specifications and tolerances and methods of tests for, and capacity rating of, master track, railroad track, grain hopper and other heavy-capacity scales, and of testing machines; and coöperation with railroads, weighing bureaus, etc., on heavy-capacity scales and weighing problems.

For the purpose of carrying on the railroad work, the Bureau has two well-equipped cars for calibrating railroad track scales, which are operated continuously for nine or more months a year. These are box cars specially constructed to hold a set of weights aggregating one hundred thousand pounds. By means of an electric crane attached to the car, the current for which is generated by a dynamo operated by a gasoline engine, these weights can be loaded onto the scale, and its readings compared with the actual load placed upon it. The Bureau also has two single dead-weight test cars weighing, respectively, forty thousand and eighty thousand pounds, for less accurate work. By this means the Bureau exercises a fundamental control over the weighing of all heavy freight in carload lots in the country, amounting in value to three or four billion dollars a year.

The Bureau, during the fiscal year 1924, tested nineteen master scales and 1019 commercial track scales distributed over thirty-seven states and the District of Columbia. The testing is mostly done with the test weights carried in the specially constructed box cars, although some of the testing is also done by the dead weight test cars.

The railroads coöperate in the work of testing master scales by furnishing free transportation for the cars used in the tests. In return the Bureau, in the course of its work of testing, also adjusts the railroads' master scales when found in error and tests such of their track scales as time will permit. The track scales on many lines are regularly tested by the railroad companies by means of their own test cars. Many of these test cars belonging to the railroads are also calibrated by the Bureau.

As practically all freight rates have some direct relation to weight, and as commodities are very frequently bought and sold on the basis of railroad weights, it is of the highest importance in commodity transportation that all track scales should be accurate and that they should be adjusted to a uniform standard. The work of the Bureau is of material assistance in accomplishing this end throughout the United States.

The Bureau has also prepared and published, as Circular 83, specifications for the manufacture and installation of railroad track scales.

The testing of mine scales and cars is specially provided for in the annual appropriation acts, the last act, approved February 27, 1925 (Pub. 502, 68 Cong.), having appropriated $14,540 for the fiscal year 1926, " for investigating the conditions and methods of use of scales and mine cars used for weighing and measuring coal dug by miners, for the purpose of determining wages due, and of conditions affecting the accuracy of the weighing or measuring of coal at the mines."

Mines scales are tested by the Bureau of Standards when requested by the operators or employees or by both, or at its own initiative in general investigations throughout the mine fields in order to insure proper compensation adjustments where the wages are based upon quantity mined. In the course of this work, experts are sent to the mines, and the mine scales are tested by means of weights carried in specially equipped motor trucks. Almost invariably both the operators and the mine workers accept the decisions made by the Bureau's experts, with the result that many labor and other disputes regarding the weighing of coal are avoided. This work has helped to bring about uniformity and to increase accuracy of weighing and thus to eliminate suspicion and allay industrial unrest on the part of the miners.

The Bureau, besides investigating the condition and accuracy of scales at coal mines, examines and tests other weighing machines, such as conveyor weighers used to weigh a continuous stream of coal, crushed stone, etc., and it has prepared specifications covering suitable types of weighing equipment for mines, and the methods of installation.

In 1921 a technologic paper (No. 199) was issued giving the results of a study of a "method for precision test of large capacity scales."

Gauge Standardization. Gauge standardization is carried on under a special annual appropriation, which for the fiscal year 1926, amounted to $38,000.[6] The work is of special importance to industries engaged in production of parts to precise dimensions, in what is known as interchangeable manufacture. In this type of manufacturing, the product is kept within prescribed dimension limits by the use of limit gauges including both end gauges, and screw gauges. The Bureau carries on tests and researches of, and certifies limit gauges used in interchangeable manufacture; designs and improves gauge-testing equipment; constructs experimental and special equipment for the inspection of gauges, gears, mechanical indicators, etc.; and constructs special gauges, such as precision gauge blocks.

It coöperates, in this standardization work, with the National Screw Thread Commission, the National Board of Fire Underwriters, the American Engineering Standards Committee, the Sectional Committee on Plain Limit Gauges for General Engineering Work, the Gauge Steel Committee, the national engineering societies, and the manufacturers and users of screw-thread products.

The Bureau also coöperates with manufacturers and users of gauges with a view to selecting the most satisfactory material available for gauges and determining the proper heat treatment for this material, in order to reduce to a minimum the loss that may occur during manufacture and to extend the useful life of gauges. To this end tests and investigations are made of the suitability of various grades of steel and of stellite as material for gauges. The Bureau has also investigated the strength, and tightness of threaded pipe joints.

The Bureau does much experimental work for the National Screw Thread Commission, which is constantly calling upon it in regard to the character of the standards to be set up for the country. The recommendations of the Screw Thread Commission concerning screw thread standards are mandatory on the Departments of War, the Navy, and Commerce, and in general they are widely accepted by the industries of this country.

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[6] See page 256.

Weights and Measures Laws and Administration. The Bureau has charge of the administration of the act to fix the standard barrel for fruits, vegetables, and other dry commodities, and the act "to standardize lime barrels," and it coöperates with the states in the enforcement of their respective weights and measures laws and regulations.

The standard barrel act of March 4, 1915 (38 Stat. L., 1186),[7] fixes the standard barrel and subdivisions thereof for fruits, vegetables and other dry commodities, and makes it unlawful "to sell, offer or expose for sale," in intrastate as well as interstate and foreign transactions, such commodities in barrels of less capacity than the standards established; and it empowers the Director of the Bureau of Standards to formulate rules and regulations for its enforcement. Offenses under this act are made misdemeanors, and prosecutions for such offenses may be begun by the weights and measures officers of the several states and territories.

The act of August 23, 1916 (39 Stat. L., 530),[7] to standardize lime barrels, establishes the standards for two sizes of lime barrels, requires the marking of the net weight, etc., on them and on smaller containers, empowers the Director of the Bureau of Standards to formulate rules and regulations for its enforcement and to fix tolerances, and provides penalties for violations.

The activities of the Bureau in connection with the enforcement of these acts involve both field investigations and tests at the Bureau.

Visits are made at times to barrel factories, often at the request of the owners, to determine whether the barrels being manufactured for use in the shipment of dry commodities comply with the provisions of the standard barrel law. Barrels are also submitted to the Bureau by manufacturers to determine whether they comply with such requirements. Reports of such tests and investigations are made to the manufacturers for their guidance.

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[7] See text of the Acts in Appendix 4.

The Bureau keeps in close touch with the activities of the various state and local departments of weights and measures, and is frequently called upon for assistance, information, and advice by public officers in all parts of the country concerning testing methods, the drafting of new laws and ordinances, and the interpretation of existing laws, regulations, specifications and tolerances; it promotes uniformity and efficiency in the administration of weights and measures laws and regulations in the several states, and to this end has instituted national conferences of weights and measures officials which have been held annually at the Bureau since 1905, except during the war period.

The Bureau keeps an up-to-date file of the national and state weights and measures laws for reference. A compilation of such laws was published in 1912, but funds have not been made available for the publication of a more recent compilation. The Bureau also keeps a complete file of information concerning foreign weights and measures, to enable it to respond to inquiries from American manufacturers of weighing and measuring equipment.

The following extracts from the annual report of the Director of the Bureau of Standards for 1923 (pages 25-27), show the need of legislation concerning definite standards for weights and measures in the United States:

> For the past 30 years the weights and measures office of the Coast and Geodetic Survey and (since 1901) the Bureau of Standards have been guided by the so-called " Mendenhall order " in administering the weights and measures laws of the United States. This order accepted the national prototypes of the international meter and kilogram as the fundamental standards of length and mass of the United States, and since 1893 our measures of length and mass in the customary or English system have been derived from these standards in accordance with the law of 1866, by which the use of the metric system was made legal and in which certain equivalents were established.
>
> These metric standards have never been specifically adopted by Congress as the fundamental standards of the United States; nor, in fact, have any other physical standards of weight and measure ever been adopted by Congress except the troy pound of the mint, which in 1911 was superseded by the " standard troy pound of the Bureau of Standards," which is derived from the kilogram in accordance with the Mendenhall order and the law of 1866.

Within the past few years it has been held by representatives of the American Institute of Weights and Measures that the official acts of the Coast Survey and the Bureau of Standards in carrying out the Mendenhall order have been without legal sanction, and that the national prototypes of the international meter and kilogram are not, in fact, the fundamental standards of the United States. It is held by the above-named organization that the fundamental standards of Great Britain are also by common law the fundamental standards of the United States. The fact that the standards of Great Britain have several times been changed since 1776, and the further fact that it is now utterly impossible to determine the value of the British yard and pound in use prior to 1776, are entirely overlooked or considered unimportant.

In the case of units of mass no difficulties have arisen, the pounds of the United States and Great Britain being practically identical.

The present legal relation between the British imperial yard and the meter is slightly different from that established for the United States by the law of 1866, as interpreted by the United States Coast and Geodetic Survey and the Bureau of Standards. According to the British order in council of 1898,

$$\frac{\text{1 British imperial yard}}{\text{1 meter}} = \frac{3600}{3937.0113};$$

whereas according to the United States law of 1866,

$$\frac{\text{1 United States yard}}{\text{1 meter}} = \frac{3600}{3937}$$

This difference, although slight, is sufficient to cause uncertainty and inconvenience in converting from one system of measurement to the other. There is a further complication in the fact that British standards of length are ordinarily intended to have their correct or nominal length when at a temperature of 62° F., while United States standards, especially those used in the industries, are very generally intended to be correct at 68° F.

It has been suggested that the logical and practical method of bringing Great Britain and the United States into harmony in the matter is for both to adopt the simple relation,

$$\text{1 inch} = 25.4 \text{ millimeters (exactly)}$$

and

$$\text{1 yard} = 914.4 \text{ millimeters (exactly)}$$

from which would be derived the relation,

$$\text{1 meter} = 39.370078 \text{ inches (approximately)}.$$

This value lies between the present legal values, and somewhat nearer the British than the United States value.

That there would be certain practical advantages in the adoption of the simple relation, 1 inch=25.4 millimeters, is admitted both by those who favor the use of the metric system and by those who oppose it. For example, in addition to the advantage of bringing Great Britain and the United States into agreement, the suggested change would make legal the relation that is already widely used in both England and America in screw cutting and similar work where it is desired to turn out a product in one system of measurement on a machine manufactured in accordance with the other system.

The arguments in favor of enacting legislation specifically adopting our metric standards as fundamental may be briefly summarized as follows: (1) It would put on a definite legal basis the standards that have been in use for the past 30 years. (2) They are the best physical standards available from the standpoint of permanency and accuracy. (3) If supplemented by a statement of the exact relation between the units of the metric and the customary system, the fundamental standards would continue to serve as the basis of both systems of units.

An objection to proposing this legislation is the danger that it will be misinterpreted as an attempt to force upon the United States the exclusive use of the metric system.

Compulsory metric legislation is considered by this Bureau to be inadvisable, and the above suggested action should in no sense be so interpreted. It should be interpreted solely as an attempt to put our weights and measures on a definite legal basis and in the end to bring about uniformity with Great Britain.

It should be borne in mind that the specific adoption of the national prototype meter and kilogram as the fundamental standards of length and mass of the United States, together with the adoption of definite relations between the customary and metric units would not in itself bring about complete uniformity with Great Britain. Similar action on the part of Great Britain would be necessary.

In case Great Britain should continue to regard the imperial yard and pound as the fundamental standards and to derive the metric units therefrom in accordance with the new relation, there would still be a slight theoretical difference. This difference, however, would be insignificant, being in the case of the yard about one-third of the present difference.

Electrical Work. The activities of the Bureau in this field of electricity are most important and extensive. In all industries in which electric energy is employed, the accurate measurement of the various electrical quantities which occur in practice is very essential. The Bureau mantains the fundamental standards upon which these electrical measurements are based; coöperates with other national laboratories to secure international uniformity of standards; develops improved standards and measuring apparatus; and tests and certifies electrical instruments and reference standards for the various government agencies and for manufacturers, testing laboratories, research institutions, public utility organizations and engineering and other interests.

Congress by act of July 12, 1894 (28 Stat. L., 101), established and defined the units of electrical measurement. Of these, the fundamental units are the international ohm, which is defined in terms of the resistance, at the temperature of melting ice, of a uniform column of mercury of specified dimensions; and the international ampere, the unit of current, defined by the rate at which silver is deposited by an electrical current, in the silver volt-meter. The Bureau is at work upon a new determination of the ohm in absolute units, a determination of the ratio of the international to the absolute henry, and the design and construction of an absolute electrometer for measurement of voltage up to 250,000.

Standards have also been and are being developed and measurements are being improved in the fields of radio communication, magnetism, and photometry.

The electrical research work is mainly concerned with methods of measurement, the determination of the electric and magnetic properties of materials, and the development of those phases of engineering science in which measurement plays an important part.

The testing of electrical instruments and apparatus is of two main classes: first, tests made for the purpose of standardization of reference standards and precision instruments for manufacturing and other institutions which make or standardize instruments for commercial use or which conduct research work; and second, tests of commercial electrical measuring instruments, radio and photometric apparatus, magnetic materials, etc., made chiefly for the purpose of keeping the Bureau in touch with the needs of the industries, of developing methods, and of improving apparatus and materials. Most of this testing is conducted for the government services and serves the purpose of providing information to be used in formulating specifications and of determining the quality of materials furnished upon specifications.

A member of the Bureau's staff is chairman of the Electrical Supplies committee of the Federal Specifications Board, which prepares specifications for electrical supplies of all kinds for the use of the government.

One of the most important services rendered by the Bureau largely in the electrical field, is the investigation of problems arising in connection with various public utilities, particularly electric light and power, street railway, and telephone services. This work includes: (1) Scientific and engineering research; (2) the study of conditions which determine the quality of the public utility service; (3) methods of testing and inspecting employed by municipalities and public service commissions; (4) safety rules for use by the utility companies to safeguard their employees and the public, which are considered under the head of safety engineering; and (5) the collection and distribution of information by publications and through correspondence. The Bureau neither has nor desires to have any authority to control the acts of public utility organizations with regard to the application of the results of its work; that being the proper function of the state and local governments.

The work of the Bureau in electricity comprises tests and researches in the specialized fields of resistance measurements and apparatus; inductance and capacitance; electrical instrument testing and development; magnetic measurements; photometry and illuminating engineering; electrolysis prevention; radio communication; electrical service standards; telephone service standards; and certain kinds of work in electro-chemistry, particularly the properties and performance of electric batteries.

Resistance Measurements. Resistance measurements include the establishment and maintenance of the ohm, the development and testing of resistance standards and apparatus, the study of methods of measurement, the investigation of electrical properties of conductors, the standardization of conductor materials, and the application of resistance methods.

Tests were made during the fiscal year ending 1924 of resistance standards; current shunts; Wheatstone, thermometer, and Thomson bridges; potentiometers; and volt boxes, conductors, and other apparatus. Many researches in this field were made, including among others, one conducted in coöperation with the Coast Guard which resulted in the development of an apparatus for determining the salinity of sea water by measurements of its electrical resistivity. A method has also been recently developed for producing at a distance, by the use of a galvanometer and other appliances, a magnified record of mechanical motions, the method being designed for use in the study of earthquakes.

Inductance and Capacitance. This branch of activity in the field of electricity consists of the establishment of fundamental standards of inductance and capacitance; the maintenance of working standards; the calibration of standards of other laboratories; the development of mathematical formulæ; investigation of methods of measurement; measurement of electric properties of insulators, dielectric constant, dielectric loss, and insulation resistance. As a by-product, methods have been developed for measurements of phenomena involving the determination of short-time intervals, and these methods have been applied to various problems in ballistics and engineering.

At the request of the Signal Corps, the Bureau has for several years been conducting an investigation of cable insulating materials, and a systematic program has been laid out and practically completed for determining the electrical properties of such insulating materials as show promise for use in submarine cables.

Studies have been made, for the Navy Department of movements and stresses in turret structures during gunfire, and of the amplitude and period of vibration of the crankshaft of a large Diesel engine. Measurements have also been made of the velocity of projectiles inside the bore of a gun, by means of a self-adjusting expansometer developed at the Bureau, which is used to determine the time at which a projectile passes a given plane across the gun. A special camera has been devised which is capable of taking 250 pictures per second, and can be used to determine the velocity of projectiles in flight, and the tumbling or other irregularities of motion which may affect the velocity.

Electrical Measuring Instruments. Under this head are included the Bureau's activities in testing electrical measuring instruments, and apparatus and accessories; the maintenance and extension of practical standards and methods for measuring voltage, current, power, and energy; research on problems related to commercial electrical measurements, comprising development of testing methods and apparatus, and studies of dielectric strength and dielectric loss at high voltage; development of specifications for electrical instruments; and various electrical tests and investigations.

In much of this work the Bureau is in close coöperation with various scientific bodies, and members of its staff take an active part in the work of a great many technical committees of such organizations.

Numerous tests are made every year of ammeters, volt meters, shunts, current transformers, and other electrical instruments, rubber and other insulation appliances, spark plugs, etc.

Magnetic Measurements. The magnetic work consists of the development and maintenance of methods and apparatus for determining the magnetic properties of materials; tests involving magnetic properties or magnetic effects; and correlation of magnetic properties with other physical properties of materials with a view to the development of non-destructive tests.

Tests regularly made include normal induction, hysteresis, and core loss. The magnetic measurement tests made are of two kinds, known as Class A and Class B. The former are limited to cases where the highest attainable accuracy is necessary; and Class B covers all other tests.

Recently a method was developed for testing small specimens, by means of which sufficient accuracy may be obtained for most research work on the properties of materials, especially materials of exceptional purity which can generally be obtained only in small quantities.

Studies are made of problems involving the relationship between the magnetic properties of steel and other physical properties, requiring for their solution a knowledge of the effect of such factors as chemical composition, previous heat treatment, cold work, stresses, etc., on the magnetic properties.

Magnetic analyses made of steel and steel products enable one to ascertain their quality as regards freedom from flaws, their strength, etc., without in any way injuring the piece examined. By this means the elimination of defective material can be effected before expensive manufacturing processes are applied.

In order to learn of the structural changes which take place in steel at different temperatures, analyses are made in which continuous observations are taken of the intensity of magnetization of specimens during heating or cooling. This is known as thermomagnetic analysis.

A special apparatus was recently designed for making magnometric measurements in certain classes of research, such as determining the effect of high temperatures on magnetic properties. By this means structural transformations in iron and steel during heating and cooling are revealed by corresponding changes in their magnetic properties.

An investigation is being made of the magnetic and other properties, of steel hoisting ropes, in the hope of finding a practicable method of testing such ropes in service, and thus avoiding the cost of unnecessary replacements of such ropes, without incurring risk of loss of life and property which result from breakage of such ropes.

In its magnetic work the Bureau coöperates with various organizations, particularly with the committees on magnetic properties and on magnetic analysis of the American Society for Testing Materials. As a result of such coöperation, this society has recently completely revised its specifications for standard magnetic tests.

Photometry and Illuminating Engineering. The work in this field comprises the maintenance of standard lamps on which all candle power and illumination measurements in the United States are based; the provision, for other laboratories, of lamps calibrated by comparison with the Bureau's reference standards; inspection and testing of lamps purchased by the government; consultation service to government departments on lighting problems; investigation of characteristics of lamps; formulation of lamp specifications; testing of lighting fixtures and accessories; investigations concerning motor vehicle lighting, including headlights, tail lights, registry plates, and signals; research on methods of measuring light; and development and calibration of photometric instruments.

The Bureau provides calibrated standards for research, university, and testing laboratories, and for lamp factories. This service is of the highest importance in view of the fact that all candle power and illumination measurements made in the United States depend on the reference standards preserved at the Bureau.

All electric lamps purchased by the government must conform to specifications which are published by the Bureau and revised from time to time as lamp making methods are improved. The tests to determine such conformity are made by the Bureau of Standards. The importance of this work becomes apparent when it is realized that the government purchases annually about one and two-thirds millions of such lamps, valued at about $650,000. It is estimated that the testing of electric lamps saves the government about $100,000 each year. The Bureau also makes such tests for some of the state governments.

At the request of the Bureau of the Budget, a survey was recently carried out of electric light and power requirements of such government buildings as could be readily supplied from a central plant, and a report was rendered to that bureau.

The Bureau's activities with regard to motor vehicle lighting include tests of headlight devices, study of the illumination required to render license plates legible under various conditions, and investigations designed to show the effect of variation in reflectors and lamps on test results. The headlight regulations used in many states are in conformity with specifications formulated by the committee on motor vehicle lighting of the Illuminating Engineering Society, on which the Bureau was represented. The specifications are based on an extensive series of road and laboratory tests, and are intended to insure a reasonably good driving light and at the same time prevent glare. The Bureau is specially equipped for making tests of headlights in accordance with these specifications.

Among other activities in the field of photometry the illuminating engineering that the Bureau has engaged in recently may be mentioned: assistance rendered the Department of Agriculture in the calibration of instruments and special filters used in measurements of light as affecting the growth of plants; study of the properties of searchlight beams; survey of street lighting practice throughout the United States; investigations on the most suitable colors for traffic signals; advice in regard to illumination in several government buildings; and many others.

Electrolysis Prevention. Electrolysis is defined as "the process of decomposing a chemical compound by the passage of an electrical current through it." Most street railways are operated on the single overhead-trolley plan, with the electric current flowing into the rails through the car wheels after it has passed through the car motors. The current then flows back to the generating station or substation by way of the tracks and the earth. Some of the current, however, often overflows through underground gas and water pipes and the lead sheaths of underground telephone and electric-light cables and sometimes through reinforced-concrete structures. When the electric current flows away from the iron pipes or lead cable sheaths, it carries away iron or lead by electrolytic action, which in time may seriously corrode the pipes and sheathing and even destroy them completely. There are also possibilities of trouble in the cases of bridge structures, steel-frame buildings, and piers which are occasionally exposed to damage from this source.

For about fifteen years the Bureau has been investigating the subject with the view of ascertaining the conditions under which electrolysis occurs and the best methods of preventing or mitigating this trouble. The surveys made in cities in various parts of the country have enabled municipalities to formulate regulations which are fair both to the utilities concerned and to the public.

Electrolysis testing has been handicapped by having only inadequate methods of determining electrolysis conditions. The Bureau has recently developed an earth current meter which measures the currents directly responsible for electrolytic corrosion. It measures the leakage current in the earth near the pipe or cable, and thus permits an accurate determination of electrolysis conditions at the point of test. The new instrument also makes it possible to study the relative merits of different methods of electrolysis mitigation more accurately than was formerly possible. The instrument is being extensively used in a number of cities.

An activity undertaken in 1922 is the investigation of soil corrosion for the purpose of determining the extent of the corrosive action of different kinds of soil on various kinds of metals used for pipe purposes and of determining the importance of this corrosion in diagnosing cases of damage supposed to be caused by stray currents. At the urgent request of and in coöperation with many public utility corporations and pipe manufacturers, this work has been expanded to include the effectiveness of bituminous and metallic coatings as a protection against soil action. About thirteen thousand specimens have been buried in forty-six typical soils throughout the United States. The Bureau of Soils of the Department of Agriculture is coöperating in this work.

A treatise is being prepared by the Bureau on the methods of testing to determine when damage from electrolysis is occurring, and improved instruments for this purpose are being developed. An extended treatise is also in preparation on the methods of avoiding or reducing damages by electrolysis.

The electrolysis prevention work is being carried on in coöperation with the American Committee on Electrolysis, consisting of twenty-seven members, representing the following organizations: American Institute of Electrical Engineers, American Electric Railway Association, American Railway Engineering Association, National Electric Light Association, American Gas Association, American Telephone and Telegraph Company, American Water Works Association, and the Bureau of Standards.

The Bureau's expenses for this work are mainly met out of the appropriation for "Investigation of public utilities."

Radio Communication. The present activities in the field of radio communication consist of the establishment of radio standards; the testing of radio instruments and devices; the development of methods of radio measurement; the preparation of specifications for radio equipment; the study of wave phenomena; the survey of interference; electron tube research; the development of radio devices; coöperation with other government agencies in radio communication; the application of radio methods; and the supplying of radio information. The cost of this work is mainly met by special annual appropriations for "radio research."

The radio communication work is chiefly concerned with the underlying principles regarding broadcasting, the actual determination of the improvements in and accuracy of the frequency measurements, and the problem of interference, all of which involve difficult technical questions.

Some tests are being made of the various instruments and appliances used in radio measurements and in the construction and use of radio apparatus.

In coöperation with the Bureau of Lighthouses, studies are being made for the improvement of radio fog-signaling devices.

Specifications have been prepared for an automatic transmitting set of electron-tube type, which is designed to modernize the beacon system, giving greater distance range and reducing interference with other radio communication. A development was recently completed of a directive system which enables a ship or aircraft to follow a specific course with the aid of ordinary receiving apparatus.

One of the most important objectives of all radio research, which is occupying the Bureau's attention, is the reduction of radio interference. To reduce interference, all transmitting stations must operate exclusively on the wave frequencies assigned them, must use as small power as required to reach the necessary distance, and must use waves which are as sharp as possible. Much attention has recently been given to the improvement of the control of frequencies or wave lengths, by developing more accurate fundamental standards and methods of measurement and calibrating many instruments for manufacturers, broadcasting stations, and government offices, and by regularly transmitting standard frequency signals from the Bureau of Standards and, for the Pacific Coast, from Stanford University.

At the request of the National Electric Light Association, the Institute of Radio Engineers, the American Radio Relay League, and many other radio and electrical interests, the Bureau has done some experimental work on electrical (non-radio) interference with radio reception, but the Bureau lacks the funds to undertake a comprehensive study of this increasingly important problem.

A statistical study has also been made to determine the actual extent and effect of interference in radio reception as experienced by broadcast listeners. With the coöperation of the American Radio Relay League, the Westinghouse broadcasting station at Pittsburgh, and the University of Minnesota, about 7200 returns were received from observers. The analysis of these returns shows that the principal obstacle to reception is interference from broadcasting stations other than the one which the listener desires to hear; next, the fading of signals; and lastly, interference from power lines. In order to obtain more definite results in this kind of work, apparatus has been developed to make actual measurements of the strength of signals received instead of merely estimating it, and coöperative observation by some thirty laboratories has been arranged.

Much attention is also given to the standardization of radio apparatus and radio service. One of the major projects engaging the attention of the Bureau is a study of electron tubes, particularly the development of methods of measuring their characteristics, the establishment of standards of performance, and the standardization of tubes for government use. A general conference of all radio interests called by the Bureau has resulted in the formation of a section committee of the American Engineering Standards Committee for radio standardization. Some preliminary work has been done by this committee with the coöperation of the Bureau, and even more progress in standardization has been made through the work of the Interdepartment Radio Advisory Committee, and the radio committee of the Federal Specifications Board.

In view of the increase in the use of the radio telegraph for broadcasting, and the resulting confusion caused by interference, the Secretary of Commerce called conferences on February 27, 1922, March 20, 1923, and October 6, 1924, to work out proposals for administrative action designed to reduce the amount of this interference. The conferences were attended by representatives of the principal commercial, public, scientific, and government organizations interested in radio communication, including the Bureau of Standards.

The first conference, after two months of public hearings, study, and investigation, unanimously recommended the immediate extension of the regulatory powers of the government, and drafted its technical provisions of a law for submission to Congress. Congress having failed to enact such provisions, a number of recommendations were made by the second conference which proved of assistance to the Department of Commerce in its task of administering radio laws which have become obsolete from the technical standpoint. The second conference resulted in the assignment of new wave frequencies throughout the whole radio range, so chosen as to reduce the then existing interference. The third conference dealt with the permissible power and range of stations, as well as a further revision of frequency assignments.[8]

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[8] See Institute for Government Research, The Bureau of Navigation, pp. 54-62.

The radio communication laws are enforced by the Bureau of Navigation, but in all technical problems relating to this matter the Bureau of Standards is in close coöperation with that Bureau. For example, in coöperation with the Radio Inspection Service of the Bureau of Navigation, a number of improvements have been made in the wave meters and other instruments used by the radio inspectors.

As a result of the first National Radio Conference, an Interdepartmental Radio Advisory Committee on Government Radio Communication was formed for the purpose of functioning as a coördinating agency and advisory body to all of the participating government departments and establishments in their use of radio communication. The Bureau of Standards is represented on this committee, giving special attention to technical problems.

The Bureau of Standards was represented at an international conference in 1921 to consider the technical problems involved in new agreements on radio connection which have arisen since the International Radio Convention of 1912. Two members of the Bureau served on the technical staff of the American delegation to the Conference on the Limitation of Armaments in 1921.

The Bureau participates in the work of the International Union of Scientific Radio Telegraphy, which is promoting international coöperation on some of the larger problems in radio communication, such as radio wave transmission phenomena, atmospheric disturbances, and methods of measurement and interference. Both the president and the secretary of the American Section of this Union are members of the Bureau staff.

The Bureau is also represented on the committee on earth currents and polar lights of the American Geophysical Union, which is making a study of the effect of the aurora on radio transmission.

Besides its publications on radio service, the Bureau carries on a large correspondence with persons requesting radio information. It publishes each month a reference list of sources of radio information in the Radio Service Bulletin.[9]

Electrical Service Standards. The activities considered under this head consist of the study of the engineering features of electric service regulations; the formulation and comparison of standards for electric service; the engineering study of street lighting practice; and the furnishing of information to public service commissions. The expenditures for this group of activities are met out of a special annual appropriation for "Investigation of public utility standards." In this work the Bureau has the active coöperation of the National Electric Light Association and the Association of Edison Illuminating Companies.

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[9] See page 240.

Public service commissions in forty states and in the District of Columbia have been empowered to ascertain and fix adequate and reasonable standards for the measurement of quality and other conditions pertaining to the light and power service rendered by public utilities, and to prescribe reasonable regulations for examining and testing such product or service and for its measurement. The Bureau of Standards is giving much attention to the study of scientific questions arising in connection with specifications for electric light and power service and the technical and engineering requirements that should be embodied by municipalities or by state public utility commissions in the ordinances, rules, and regulations promulgated by them for the government of public utilities.

The Bureau has assisted in the revision of the Electrical Motormen's Handbook of the National Electric Light Association, and has been given joint responsibility with that association and the Association of Edison Illuminating Companies for the revision of the meter code, which includes requirements for all meters used in ordinary power sales.

In 1916 was published a circular (No. 56), entitled "Standards for electric service," a revision of which was recently completed. It is an exhaustive summary of the technical and engineering features of electric service regulation by commissions and municipalities, and includes a digest of all state rules and municipal ordinances now in force. This circular has been used by many state officers as a basis for their service standard rules.

Municipal authorities have difficulty in obtaining adequate information on which to base the terms of street lighting contracts and to specify the service to be rendered. The Bureau is collecting information regarding street lighting practice in municipalities of 10,000 population and over, covering installation, service requirements, and contract conditions. This information will be published for the use of municipal authorities, municipal engineers and city electricians, and it has made helpful suggestions in numerous street-lighting negotiations between municipalities and electric light and power companies.

The Bureau of Standards is represented on the Standards Committee of the American Institute of Electrical Engineers and on the United States National Committee of the International Electrotechnical Commission. In coöperation with the first-mentioned, the Bureau has recently prepared a report on graphical symbols for electrical engineering use, and a translation of standards of the American Institute of Electrical Engineers into Spanish.

Telephone Service Standards. The activities in the matter of telephone service standardization consist of determining measures for both quantity and quality of telephone service suitable for general adoption as standards and furnishing information concerning the same; rendering consulting telephone engineering service to the national and state governments; establishing and maintaining standard of electromotive force; investigating the mathematical theory of submarine cable telegraphy; and testing standard cells and other telephone appliances particularly special equipment for government use. The cost is largely met out of a special annual appropriation for "Investigation of public-utility standards."

The determination of standards of telephone service required the preliminary collection, on a large scale of data concerning the design and operation of all types of telephone systems, manual, automatic, and semi-automatic, and an analysis of the telephone service into the elementary parts to each of which measures are applicable. The results of this preliminary study were embodied in Circular 112, entitled "Telephone service," published in August 1921. With this material as a basis the Bureau is engaged upon the work of determining the most suitable measures of quantity and quality of telephone service.

At the request of the Bureau of the Budget, the Bureau of Standards recently undertook a survey of the entire government's telephone service in the District of Columbia, which has resulted in a total annual saving of $69,000 without deteriorating the service and additional economies of near $26,000 per annum are in sight. The economies effected were mostly in the nature of increased efficiency in the utilization of facilities, bringing about more equitable rates, efficiency by consolidation of operating loads, and the proper checking of bills. It is claimed that in no cases have these economies impaired the quality of the telephone service. Similar surveys by the Bureau have been ordered for Baltimore, Philadelphia, New York, and Boston, and are in progress. A representative of the Bureau is chairman of a committee appointed by the Federal Specifications Board to consider the matter of standard specifications for government purchase of telephone equipment.

Electro-Chemistry (*Batteries*). The Bureau of Standards makes tests and researches concerning batteries, including the investigation of factors affecting the performance of batteries; tests primary and storage batteries and materials; coöperates in the commercial standardization of batteries; formulates specifications and standard methods of testing batteries; studies and makes comparative tests of rectifiers; conducts research on single potential measurements; and makes investigations of the silver voltameter. Tests are regularly made of all types of batteries and of battery materials and battery containers for all branches of the government service. The expenditures for this work are largely paid out of the annual appropriation for "salaries," but part of the research work is supported by funds transferred from other departments, particularly the Navy.

At the request of, and in coöperation with the Federal Specifications Board, the Bureau has recently given attention to the preparation of specifications for dry cells and for various types of storage cells, and also for sulphuric acid. The standardization of dry cells and flashlight batteries has occupied the Bureau's attention for several years.

A conference of manufacturers and large users of dry cells to consider the standardization and specifications for dry cells was held at the Bureau on December 5 and 6, 1921. The conference considered seventeen different sizes of dry cells and standardized seven; it considered thirty different sizes and kinds of flashlight batteries, and adopted eight of these as standards; it considered thirty assembled batteries, containing larger sizes of cells, and standardized six; and it standardized two sizes of batteries for radio apparatus. The conference agreed on general requirements of performance for each of the standards, and requested the

Bureau to make tests to determine the minimum performance to be required on cases where sufficient information was not already available, which tests have been made; also to prepare its specifications for dry cells to conform to the standardizations of the conference. Such specifications were prepared and published. A second conference held April 28, 1924, recommended the retention of the sizes adopted as standard by the first conference and also recommended standard tests for radio batteries.

An investigation is being made of airplane storage batteries submitted by the Navy Department with a view to developing characteristics of tin plate batteries, including the relation of capacity and rate of discharge, temperature, life, weight, and volume. Preliminary specifications for airplane batteries have been prepared.

Considerable attention has recently been given to the study of storage battery electrolytes, including particularly investigation of the effects of impurities in the electrolytes, the preparation and properties of jelly electrolytes, and an investigation of patent electrolytes.

At the request of the Bureau of Home Economics of the Department of Agriculture an extended investigation was recently made on the tarnishing and detarnishing of silver, including also a study of the effect of wrapping paper on the tarnishing of silver.

Other studies recently concluded in this field are: Crankshaft acceleration measurements, undertaken at the request of the Army Air Service; a study of the physical properties of lead-antimony alloys used for storage-battery grids, undertaken at the request of the Bureau of Aeronautics of the Navy Department; an investigation to find a suitable method of measuring the porosity of storage-battery plates; and an investigation of rectifiers for battery charging.

The Bureau coöperates with outside committees dealing with battery problems, questions recently considered by such committees having included railway batteries and storage batteries for automotive purposes.

Safety Engineering. For over ten years the Bureau has been engaged upon the problems of accident prevention in the various lines of industry, in which task it has actively coöperated with leading public administrative, industrial, and scientific organizations throughout the country. It is endeavoring to promote safe, efficient, and economical practice in the operation of utility companies, and reasonable uniformity in the technical requirements of state and local commissions which control such companies. This work, which has very greatly expanded since its beginning, consists of the preparation and revision of safety standards; study of technical problems in traffic control; investigation of accidents and of conditions and practices in industry; and preparation of publications bearing on the application of safety standards. The expenses of this service are mainly met out of the appropriations for "Investigation of public utilities standards," and "standardization of instruments and equipment."

The Bureau is represented in the Safety Code Correlating Committee, which has recommended a large number of safety codes to the American Engineering Standards Committee. Upon the invitation of the latter, the Bureau has accepted sponsorship for the following codes: Electrical safety code; gas safety code (joint sponsorship with the American Gas Association); code for the protection of the heads and eyes of industrial workers; combined electrical fire and safety code; code for protection against lightning (joint sponsorship with American Institute of Electrical Engineers); safety code for logging and sawmill operations; safety code for aeronautics (joint sponsorship with the Society of Automotive Enginers); code for the colors of traffic signals (joint sponsorship with the National Safety Council); and safety code for elevators (joint sponsorship with the American Society of Mechanical Engineers and the American Institute of Architects).

The Bureau is also represented upon a number of sectional committees organized by other national bureaus and by engineering societies which are sponsors for and are developing safety codes.

Electrical Safety Code. The Bureau has long been engaged upon the work of preparing and revising a code for the establishment of a standard of safe construction and operation for high-voltage transmission lines, involving, among others, the questions of power measurements, the regulation of voltages, etc.

In coöperation with a large number of engineers connected with both private and public organizations, including representatives of state governments, public utilities, and engineering bodies throughout the country, it has been studying the life hazards in electrical practice and has been engaged in the preparation and application of the National Electrical Safety Code. The code now in use is the third, revised, edition published under date of October 31, 1920, and is known as Handbook 3. This code, which is being generally applied throughout the country, consists of: (1) Rules for the installation and maintenance of machinery, switchboards, and wiring in central stations and substations; (2) rules for the construction and maintenance of overhead and underground lines for the transmission and distribution of electrical energy and intelligence; (3) rules for the installation and maintenance of electrical apparatus and wiring in factories, residences, and wherever electricity is utilized for light, heat, or power; (4) rules to be observed by operators in working on or near electrical machines or lines; and (5) rules for the grounding of circuits and equipment, contained in a supplementary section of the code.

Observance of the code assures an adequate measure of safety and a useful standardization of practice, without involving an unreasonable expense. In its preparation careful attention was given to the varying conditions in different geographical sections and in thickly and thinly populated districts. Seven states have made the application of this code mandatory by law, and other administrative bodies require its application by regulation. It has been approved by the American Engineering Standards Committee as an American standard.

A fourth revision of the National Electrical Safety Code is now in progress at the Bureau.

The Bureau is also preparing a pictorial edition of the rules of the code, showing their application by illustrations, which will be known as the " Pictorial electrical safety code," and a volume of engineering data referring to matters connected with the rules or with overhead line construction, to be known as the " Line construction handbook."

The Bureau of Standards is a member of the Electrical Safety Conference, which was organized to promote the orderly, consistent, and proper development of practice in electrical manufacturing and installation with regard to accident hazards. This organization is now working out detailed standards for construction and installation of apparatus in harmony with the Electrical Safety

Code, having already adopted standards for industrial control equipment, rotary machinery, switchboards, oil switches, and circuit brakers. The other members of the conference are representatives of the Associated Manufacturers of Electrical Supplies, the Electric Power Club, the National Bureau of Casualty and Surety Underwriters, Underwriters Laboratories, National Electric Light Association, and the Association of Electragists-International.

Gas Safety Code. The American Gas Association and the Bureau of Standards, as joint sponsors, are coöperating in the preparation of a new draft of a national gas safety code, covering the proper arrangement and use of fixtures and appliances employed in the gas industry from the gas plant to the consumer. The new draft is largely based on a preliminary version drawn up by the Bureau. The proposed new code is designed for the protection of gas-company employees and customers and of casualty and fire insurance interests, by indicating means of preventing avoidable accidents due to ignorance or carelessness in the use of gas and to faulty installation, and also for securing uniformity of practice in gas installation and gas company operation throughout the country.

Code for Head and Eye Protection. Of the codes above enumerated that for the protection of the heads and eyes of industrial workers was first issued in 1921 and was revised and republished in 1923. It has been approved by the American Engineering Standards Committee. This code indicates the types of protection needed in various groups of industries, and includes specifications for goggles, helmets, and other devices for such protection.

Code for Protection Against Lightning. As joint sponsor with the American Institute of Electrical Engineers, the Bureau has organized a sectional committee of the American Engineering Standards Committee to prepare a code for the protection of buildings and other property against lightning. This work, which is in progress, consists of three parts: (1) The protection of persons, buildings, livestock, ships, smokestacks, trees, balloons, airships, and hangars; (2) the protection of structures containing liquids and gases; and (3) the protection of electrical lines and apparatus.

Other Safety Codes. A logging and sawmill code was completed and published on October 12, 1923. It covers the various phases of the industry from the felling of standing timber to the handling and storing of the finished product in the mill, including such details as the operation of logging railroads, rafting and driving logs in rivers, handling of explosives, guards for sawmill machinery, and precautions against fire.

An aeronautical safety code is being prepared in coöperation with the Society of Automotive Engineers. It will include the requirements for the construction and operation of airplanes and balloons and their power plants; requirements for landing fields, etc.; and it will specify the qualifications for aviators and the traffic rules to be observed in the navigation of the air.

A revision of an elevator safety code, which was originally prepared by the American Society of Mechanical Engineers with the coöperation of the Bureau of Standards, has been made by these two organizations, as joint sponsors, and with the coöperation of the American Institute of Architects. The revised code will contain one set of rules for the construction and installation of new elevators and escalators and another set of rules for existing installations.[10]

Heat and Power Measurement and Research. This group of activities deals with the question of the development of temperature control, the instruments and methods to be used and the characteristic thermal constants of the products involved. These investigations are important to industries dependent largely on temperature control, such as the metallurgical, glass, and chemical industries. A special annual appropriation is made for this work under the caption " High temperature investigations."

The work in this field includes the establishment of the standard scales of temperature throughout the range of measurable temperatures; testing and standardizing thermometers, pyrometers, and other temperature-measuring instruments; determining, by precise heat measurements, specific and latent heats, heats of reaction, melting and freezing points and other properties of materials;

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[10] The American Engineering Standards Committee, 29 West Thirty-ninth Street, New York, and the United States Bureau of Labor Statistics, have published a number of safety codes not mentioned above. Information concerning them can be obtained by applying to those organizations.

standardization of calorimeters; production and distribution of standard heat and temperature samples; industrial application of heat and temperature measurements; determining fundamental engineering data involving thermal constants; and cryogenic, or low-temperature, laboratory work. These activities are distributed by the Bureau among four groups: Thermometer laboratory work; high temperature measurements; heat measurements; and cryogenic, or low temperature, laboratory work.

Thermometer Laboratory Work. The testing of thermometers is one of the basic and essential services, which the Bureau renders to the scientific and industrial laboratories of the country. Thermometers which upon testing are found to meet the requirements of the Bureau are officially certified. During the fiscal year 1924, nearly thirty-three thousand laboratory, clinical, and other thermometers were tested. The thermometer laboratory work also includes researches on standardization of temperature scales from the lowest attainable temperature to about 500° centigrade, and the maintenance of working standards within this range; methods of standardizing temperature-measuring instruments, such as liquid in glass thermometers, vapor pressure thermometers, resistance thermometers, and miscellaneous temperature tests. With the view of securing uniformity in basic temperature standards, a conference was had with the standardizing laboratories of England, Germany, and the Netherlands which resulted in substantial agreement as to a uniform international temperature scale.

High Temperature Measurements. This activity includes researches on the standard scale and temperature and thermometric fixed points in the interval from 500° centigrade up to the highest attainable temperature; maintenance of working standards within this range; standardization and distribution of standard samples for thermometric fixed points; methods of standardization, and testing and certification of pyrometers; physical properties of materials at high temperatures; ionization and radiation in gases and vapors, etc.; industrial pyrometry; and measurement of temperatures in industrial processes.

Pyrometric research is being primarily directed toward the establishing of a standard, easily reproducible, high-temperature scale. This involves extensive investigation of means for maintaining high temperature and of the methods for producing metals of exceedingly high purity, and of maintaining their purity for the determination of melting points. Temperature scale standardization work, recently completed, involved the determination of the melting point of palladium, establishment of purity of metals used for fixed points, and the development of an optical pyrometer and micropyrometer of high precision.

Heat Measurements. This activity covers measurements, over a wide range of temperature, of the thermal properties of materials, such as specific heats, latent heats, pressure—volume—temperature relations for liquids and gases; heats of reaction, particularly of combustion of solid, liquid, and gaseous fuels; and heat transmission and thermal conductivity; also development of calorimetric apparatus and methods, and work on methods of temperature control, and pressure measurements.

A study is now in progress of the properties of saturated steam and water, which was undertaken with the coöperation of the American Society of Mechanical Engineers. It is designed to yield data of high accuracy on fundamental physical constants and to contribute toward the solution of modern problems of steam engineering.

The investigation of heat transfer through various types of wall construction is under way. A special laboratory in which a low temperature can be maintained on one side of the experimental panel and a high temperature on the other side, has been fitted up, in which specimens of typical construction can be rapidly and accurately tested.

Cryogenic Laboratory Work. The work done in the cryogenic laboratory concerns itself with the production of low temperatures down to those of liquid hydrogen and ultimately liquid helium, the preparation and storage of pure gases, the development of methods of producing and maintaining low temperatures, liquefaction and separation of gases at low temperature, and special tests requiring the facilities of a low-temperature plant.

A liquid-air plant is maintained for supplying the liquid air requirements of the Bureau and occasionally the needs of other scientific institutions; a carbon dioxide plant mainly to supply refrigeration for heat researches of the Bureau and for use in testing aviation and other instruments at low temperatures; and a liquid hydrogen plant for producing liquid and solid hydrogen when required. Researches have recently been made in the nature of production, analysis, and liquefaction of hydrogen, and a new type of vacuum-insulated container has been developed which is intended to hold liquefied gases and for other uses requiring especially good insulation. The necessary compressor and other apparatus for liquefying helium are now being installed.

Investigation of Fire Resistive Properties of Building Materials. The investigation of the fire-resistive properties of structural materials was undertaken for the purpose of furnishing architects, engineers, builders, state and city building inspection bureaus, insurance interests, and others with fundamental engineering data concerning the behavior and safety under fire conditions of the various types of building materials and construction. A special annual appropriation is made for this work.

The Bureau makes fire tests of structural materials and structural members; conducts investigations to develop engineering data relating to the general fire-resistive features of building construction; makes tests of fire prevention and fire retarding devices; investigates testing conditions and testing methods with a view to standardization; and makes recommendations for proper fire provisions in building codes and fire codes.

Experiments are being made to obtain information on the intensity and duration of typical building fires. A fireproof building erected for such experiments is furnished inside with materials corresponding to various types of occupancy and set on fire, and the intensity and duration of the fire are observed by means of temperature measurements at many points. These experiments are necessary for the standardization and interpretation of fire tests of materials and constructions.

Tests have recently been made of several types of theatre curtains, resulting in the formulation of specifications looking to their safe production. Elaborate investigations are also being made on the fire-resistive properties of various kinds of roofing materials, and the behavior of different wall constructions.

At the request of the Post Office Department there have been carried out by the Bureau, full-scale tests, of resistance to fire of several kinds of safes and filing cabinets, and the question of the standardization by a test procedure has been investigated.

Standards of practice for use in fire regulations, building and safety codes, and specifications, are also developed.

Study of Automotive Power Plants, Fuels, and Lubricants. For about eight years the Bureau has been carrying on investigations of the performance characteristics of automotive power plants, their accessories, fuels, and lubricants. This work consists of complete performance testing of aircraft power plants under altitude conditions, and of automobile engines both in the laboratory and on the road; laboratory and service tests of the performance of aircraft and automobile fuels and lubricants; testing of power plant accessories both for aircraft and automobile engines, such as carburetors, ignition apparatus, radiators, etc.; testing of automobile chassis units, such as rear axles, transmissions, brake linings, etc.; and investigations of a fundamental nature dealing with the theory, design, and operations of internal-combustion engines, such as the rates of gas reactions at high pressures and temperatures, cylinder pressure measurements in high-speed engines, theoretical possible thermal efficiencies, etc.

In carrying out these activities the Bureau closely coöperates with the military branches of the government, the National Advisory Committee for Aeronautics, the American Petroleum Institute, the Society of Automotive Engineers, and the National Automotive Chamber of Commerce. Many of the investigations have been sponsored directly by the National Advisory Committee for Aeronautics, the engineering division of the Army Air Service, McCook Field, Ohio, the motor transport division of the Quartermasters Corps of the Army, and the Bureau of Aeronautics of the Navy Department.

These activities, which began during the war period, were, in past years, paid for largely from military funds. Much of the equipment, which is valued at over $300,000, and some of which is not duplicated anywhere, is inherited from military appropriations. A special appropriation of $25,000 for "Investigation of automotive engines" was made for the first time for the fiscal year 1925, and was repeated ($20,680) the following year. The entire annual cost of this work, however, is about $80,000, some funds being transferred from other departments and the balance being in the nature of services rendered by persons in the employ of the Automotive Chamber of Commerce and the Petroleum Institute who are stationed at the Bureau.

Automotive Engines and Accessories. Studies are being made in vacuum chambers, which simulate pressure and temperature conditions of flight, of the performance of aircraft engines as affected by altitude, such as the effect of changes in carburetor air temperature upon engine power, changes in air fuel ratio on engine performance, and changes in compression ratio on engine performance. The Bureau possesses the only existing equipment for performance testing of aircraft engines at altitudes. It has developed a method whereby approximate altitude performance tests of aircraft engines can be made at other stations not possessing the special equipment for the precision work done at the Bureau.

Ignition problems, which are also considered under electrical activities, consist mainly of certain specific investigations requested by the Army Air Service and the National Advisory Committee for Aeronautics; studies of ignition systems; and tests of spark plugs and attachments for various government departments, municipalities, and, in special cases, for manufacturers.

With regard to carburetion, investigations have recently been made of the metering characteristics of carburetors for the engineering division of the Air Service; tests of the performance of carburetors at varying altitudes, in the altitude laboratory; and investigations of fuel atomization in carburetors. A new carburetor-testing plant for both automobile and air craft carburetors is being constructed.

An investigation is being made of the friction losses in journal-bearings and on the cylinder walls of engines in order to determine the amount of power consumed, and especially to bring about improvements in design and operating efficiency.

Among the cooling problems recently dealt with are: an investigation of the air flow through airlpane radiators in flight, undertaken at the request and with the support of the National Advisory Committee for Aeronautics, a method having been developed for taking their measurements; and a critical study of the behavior of Pitot tubes as used to measure the air flow through the cells of aircraft radiators.

In coöperation with the motor transport division of the Quartermaster Corps of the Army and the Standards Committee of the

Society of Automotive Engineers, the Bureau is carrying on an extended investigation to ascertain the best conditions for a standard test for brake linings. The investigation covers the coefficient of friction of lining, the influence of water, oil, wear, and temperatures on this coefficient; tests of durability by means of long-time runs and severe service runs; and other supplementary tests. This investigation has disclosed the fact that there is a very wide difference in the performance of brake linings in the market which are sold to the consumer at the same price for a given size, and a general agreement has been reached in the industry on the value of a standard method of testing. As a result, a marked increase has been shown in the durability of brake linings produced by many manufacturers. The various branches of the government service are basing their purchases on the Bureau's tests. The Bureau has estimated that this investigation alone saves the public at least $15,000,000 per year.

The Bureau has recently completed an investigation of the efficiency of brakes, which is of the utmost importance to the safety both of automobile drivers and pedestrians. A recording and an inspection decelerometer have been developed to permit measurements of the braking ability of automobiles. Representatives of the Bureau have been invited to explain and use these decelerometers at demonstrations carried out in several of the larger cities, resulting in increased information for the promotion of greater safety of traffic. Tests made on automobile tires point to possible savings of 5 per cent of all gasoline used by adopting the results of the Bureau's tests. Among other recent activities in this field are the development of a high-speed recording pressure indicator, investigations of the mechanical efficiency of truck rear axles, of the road performance of engines and cars, tests of automobile headlights, etc.

Fuels and Lubricants. Studies concerning fuels for internal combustion engines include experiments in blending gasoline in various proportions with alcohol, benzol, and other materials, in order to prevent the destructive detonation resulting from the use of gasoline alone in high-compression aircraft engines; economic motor fuel investigations, in coöperation with the American Petroleum Institute, the National Automobile Chamber of Commerce, and the Society of Automotive Engineers, to find the conditions under which differences in the fuels have a considerable effect upon engine performance, and to evaluate the magnitude and importance of such differences; also studies relating to intake manifold temperatures.

The results of researches prior to July, 1924, concerning fuels adapted to use in high compression aircraft engines have been summarized and made available.

A research, recently made, shows that heavier grades of gasoline could be used in average service with resulting economy in the operation of motor vehicles, except for certain limiting factors such as crank-case oil dilution and starting difficulties which are being studied.

A study now under way of the volatility of various grades of gasoline is expected to increase the supply available for automotive purposes. An investigation is being made of the methods available for determining and specifying the degree of volatility of motor fuels to meet the requirements of automobile engines with the view of establishing a standard method of specifying such volatility.

An investigation is under way of so-called fuel improvers. Nearly all of those listed so far have been found to be useless.

Lubrication research recently undertaken includes studies of oxidation of oils, " carbon " deposits, gear lubrication, low temperature effects, and viscosity of lubricants; measurement of " oiliness " of lubricants; reclamation of used petroleum lubricating oils; and other studies, some of which are carried on in coöperation with Army Air Service, the American Society for Testing Materials, The American Petroleum Institute, and the National Electric Light Association. In addition to the laboratory engine tests on lubricants, a satisfactory procedure has been developed for tests on fleets of vehicles in actual service, and comparisons are being made between the performance of oils differing in definite particulars.

Information Service. A considerable part of the Bureau's work in connection with automotive power, fuels, and lubricants, consists of preparing and furnishing information on scientific and technical subjects by means of extensive correspondence, special reports, and by personal contact with technical persons who visit the Bureau's laboratories.

Work in Optics. The activities of the Bureau carried on under this head consist of: spectroscopic tests and researches covering radiation and absorption spectra, including the periodic characteristics of chemical elements, certain phases of qualitative and quantitative chemical analysis for which these spectra are especially applicable, and the development of infra-red photography for astronomical observations and for aviation purposes; polarimetry investigations and tests involving measurement of polarized light and its application, especially in the standardization and technology of sugar, including the supervision of sugar laboratories of the Customs Service; work in colorimetry, or the measurement of the factors which determine color, the optical transmissive and reflective properties of materials, and the color grading of light sources and materials; tests and researches in refractometry, including the performance and development of optical instruments and materials, refractive indices and dispersion measurements; work in radiometry involving the determination of fundamental constants of radiation, the development of radiometric methods and instruments, and the determination of the emissive, reflective, and absorptive properties of materials for thermal radiation; photographic technology work covering the testing of photographic materials and devices, and general photographic investigations; and tests and researches in interferometry, including application of the light wave as a standard unit for high precision length measurements and development of interference methods. The Bureau also includes atomic structure and X-ray measurements under this head.

Spectroscopy. Many problems in metrology, optics, spectroscopy, and astro-physics require for their solution a satisfactory system of standard wave lengths, and investigations have recently been completed in coöperation with the Allegheny Observatory, at Pittsburgh, for the determination of secondary standards in the visible and ultra-violet arc spectrum of iron; also for the determination of secondary standards in the red and infra-red arc spectrum of iron. The Bureau, in coöperation with this observatory, has undertaken a complete standardization of the solar spectrum based on the international system of units. This program is planned to cover eleven years, so as to reveal any variation which may arise during a sun-spot cycle.

In the determination of standard wave lengths the Bureau has coöperated with scientific organizations in other countries. At a meeting of the International Astronomical Union in Rome, a few years ago, that organization adopted nearly all the Bureau's work and suggestions, such as the retention of the cadmium red line as the primary standard for precision length measurements.

For about nine years the Bureau has been engaged in investigations of arc spectra of chemical elements, resulting in the discovery in each case of hundreds of new spectral lines in the red and infrared spectral regions, representing important additions to spectroscopic data. It has investigated, as far as modern photographic technique will permit, the long-wave portions of the ore spectra of nearly all of the known chemical elements. A similar investigation is planned on the longer wave portions of the spark spectra of the chemical elements.

Researches are being made on the regularities in the arc spectra of a number of chemical elements, the results of which are of marked value in developing theories of radiation and atomic structure.

A quantitative investigation of the germicidal effect of ultraviolet radiant energy has been made. It dealt with the amount of killing as effected by wave length and intensity of radiation and also time of exposure.

Many spectrographic analyses have recently been made on a large variety of materials, and whenever possible the results have been checked by standard chemical analyses. The spectrograph has successfully demonstrated its practical value in supplementing chemical methods of analysis, and in certain cases it may replace the more tedious wet methods both for qualitative and quantitative results. The Bureau has prepared and furnished many spectrum tubes containing various gases to other laboratories for optical testing or spectrum standards.

Polarimetry. The investigations and tests involving measurements of polarized light, have their practical application chiefly in the testing, standardization, and technology of sugar, and include the supervision of the sugar laboratories of the Customs Service. An annual special appropriation is made by Congress for "Sugar standardization."

In order to fix the amount of the tariff duty on sugar imported into the United States it is necessary to determine its purity. One of the most important tests of purity is the polarimetric examination of sugar. The Bureau therefore exercises an important function in connection with the inspection of imported sugar, as the amount of duty paid on such sugar depends upon tests controlled by or made at the Bureau. A sample of every cargo of sugar coming into the country is sent to the Bureau, where it is tested in the same way as at the ports of entry. The Bureau also tests the instruments used for this purpose at the ports. By this means about $100,000,000 of revenue are controlled.

Coöperation is also maintained with the American sugar industry, and progress is being made in solving one of the most important problems confronting the beet sugar producers, namely, the utilization of beet molasses. Through researches of the Bureau, American manufacturers are now able to produce a number of rare sugars, which are extremely important in pathological researches, in quantities and at prices comparable with those existing before the war, when Germany was practically the only source of these materials.

The Bureau has recently developed a method which may permit the preparation of levulose at a price low enough to put it on the market. This sugar is the sweetest and one of the most wholesome and nutritious of all sugars. By this method levulose, prepared from Jerusalem artichokes, can probably be manufactured at a cost comparable with that of beet sugar.

A great variety of tests and researches relating mainly to sugar are annually undertaken. These investigations, which to some extent vary from year to year, covered the following ground during the past two years: Rotation and rotary dispersion of sugars; acidity measurements of sugars; saturation relations in sugar mixtures; analysis of sugar by enzymes; density of invert sugar solutions; the effect of ultrafiltration upon the optical properties of solutions of technical sugar products; elimination of non sugars; polarimetric analysis of crude beet products; determination of malic acid in maple sugar sand; standardization and color standardization of commercial sugars; measurement of color in the various steps involved in the manufacture of sugar and its by-products; growing of crystals of various sugars, also crystals of

Rochelle salt and of tartaric acid; molasses formation; utilization of molasses, testing molasses sirups, etc.; investigation of methods of analysis to determine the per cent sucrose and the per cent reducing sugars in imported molasses for tariff purposes at the request of the Treasury Department; production of levulose; investigation of the physical properties of glass; double refraction in strained materials; refractrometric estimates of solids; adjustment and standardization of polariscopes and saccharimeters; development laboratories for sugar technology; development of a rapid and accurate balance for weighing sugar; and development of a calibrating instrument for graduating sugar flasks.

The sugar tests are made with a polariscope, an instrument used for measuring the quantity of sugar, its strength, purity, or sweetness, these conditions being correctly and mathematically determined by a certain characteristic dependent upon its ability to rotate a beam of polarized light. The light, vibrating in one plane only, if it is sent through sugar dissolved in water, will be rotated through a certain angle, say 90 degrees, if it is pure sugar. If it is less than 100 per cent pure, the beam of light will be rotated something less than the amount for pure sugar. This angle of rotation is read off on a dial and thus the purity of sugar is measured.

Colorimetry. This activity consists of the specification and standardization of colors and investigation of the phenomena and laws of color vision. Colorimetry deals with measurements relating to light, and defines the color of a substance as the color produced by the light transmitted or reflected by the substance under prescribed conditions. The Bureau standardizes color by determining the wave length and intensity of light. A special appropriation is annually made by Congress for "color standardization."

These studies in colorimetry are closely related to others of the Bureau, such as photometry, radiometry, and photography. They find practical application in the fact that standards of quality for materials involve scientific specification of color, where color is an indication of the quality of a material as in chemistry, ceramics, and pyrometry, and in the testing of textiles, paper, flour, paints, dyes, inks, oils, soap, butter, tobacco, and other materials, and in the specifications and regulations governing the use of railroad and other signals and eye-protective glasses. The work done in color terminology is especially complete. A very satisfactory monochromatic colorimeter has recently been developed.

In recent years, tests and researches were made concerning spectrophotometric and spectroradiometric methods; standard data were obtained on optical properties of materials which determine their color, such as dyes, glasses, enamels, vegetable pigments, vegetable oils, and other materials; visibility of radiant energy; the photometry of incandescent sources by the method of rotary dispersion; color temperature of artificial light sources; spectral distribution of energy from complete radiator tables and graphs; and spectral reflection of enamels. The researches relating to the optical properties of dyes and vegetable pigments were made in coöperation with the Department of Agriculture.

At the request of and in coöperation with a private color company investigations were undertaken from March, 1922, to February, 1923, on some of the fundamental problems of color standardization, all the work being done in the Bureau's laboratories with its own facilities, the company paying the salary of a research associate. These investigations resulted in the development, construction, and installation in the Bureau of new, improved, and satisfactory apparatus for the analysis of color stimulus in terms of dominant wave length and purity; preparation of plans for the determination of hue sensibility to wave-length difference; continuation of investigation of the psychologic standard of white light previously begun at the Bureau; further theoretical and experimental studies on the colorimetry and photometry of daylight and incandescent illuminants by the method of rotary dispersion; observations to obtain preliminary data on the color of daylight at Washington, D. C.

Some of the work carried on in 1924 in the field of colorimetry consisted of, studies concerning color transmission through two important dyes for vegetable oils, carotin, and zanthophyl; the spectral transmissive properties for seven paint pigments used as flavoring materials; preparation of a large amount of data on color properties of vegetable oils; determination of the colors of various artificial sources of illumination; and an investigation of the fastness of dyes for certain textiles.

Refractometry and Optical Instruments. The activities carried on under this designation consist of the designing and testing of optical glass, instruments, and systems, and the construction of optical components, and research in refractometry.

A very important recent activity was the testing of photographic lenses for the Army Air Service. Measurements were made of the observations, aperture ratios, and focal lengths of such lenses, in order to determine the types of lenses most suitable for use in airplane photography. By means of these tests the Bureau has acquired a collection of data on the performance of practically all high-grade photographic lenses on the market upon which a standard of excellence may be placed.

A very complete investigation of the aberrations of photographic lenses was recently completed and the results published. From the results, conclusions can be drawn regarding the uniformity of product or photographic lenses as commercially produced and the types of correction which are characteristic of the different objectives.

The Bureau is developing a series of laboratory telescopes of standard design and is preparing tables to be used in the design of telescopic systems. At the request of the Ordnance Department of the United States Army an objective was designed for a large camera obscura, and three small camera obscuras were designed and constructed for use in connection with proving work; and at the request of the Coast and Geodetic Survey a magnifying stereoscope for use in viewing photographs taken from airplanes for the construction of maps, was designed and constructed. A field telemeter was recently developed for the use of the Geological Survey in reconnaissance or approximate surveying. Other optical instruments recently designed are an auto-collimating device for the Bureau's Geneva Society spectrometer, and a number of direct vision spectroscope prisms. An apparatus was installed for measuring transmission of optical glass.

The Bureau has made many tests in recent years covering the determination of indices of refraction, transmission of optical glass, measurement of focal length and of aberrations, binocular tests, refractometer standardization and many others.

Radiometry. The Bureau's activities in radiometry consist of tests and researches on matters pertaining to thermal radiation; the development of instruments and methods of radiometry; the investigation of the emissive, reflective, and absorptive properties of materials for thermal radiation; and the testing of glasses for protecting the eyes from injurious thermal reaction.

Studies have been made in recent years of colored glass, varnishes, etc., for excluding the ultra-violet rays of sunlight from balloon hangars and other buildings containing materials which are injured by photochemical action; also an investigation of the most efficient roofing material which will keep the inside of the balloon hangar at a minimum temperature when exposed to the sun. Studies were likewise made of the emissivity of cotton tent cloth.

Radiometric measurements in paints and other materials showed that paints containing aluminum or bronze pigments are very poor radiators. When such paints are used on household radiators about 20 per cent more surface is required for the same heat effect as when other paints are used. Such paint, however, reduces the amount of heat from the sun which gets through the top of an automobile or ice wagon or through a tent.

In collaboration with the Bureau of Plant Industry of the Department of Agriculture, experiments have been made of the germicidal action of ultra-violet radiation.

By the application of radiometry to astronomical problems, by means of a thermocouple of special design developed at the Bureau, results have been obtained which open up a new line of investigation on stellar evolution, stellar temperature, variable stars, planitary radiation, etc.

Other recent activities in the field of radiometry include various photo-electric investigations, experiments on the direct transformation of light into electric current; and an investigation made for the Public Health Service on the radiation characteristics of quartz mercury vapor lamps used for therapeutic purposes.

Radioactivity Work. For about ten years the Bureau has been making tests and researches in the field of radioactivity. These activities include the measurement and certification of radium and mesothorium preparations and self-luminous surfaces and materials; the measurement, without certification of the radioactivity of weakly radioactive solids, slimes, waters, solutions, and other preparations for developmental, experimental, and commercial purposes; and the furnishing of information to the general public on radium and radium preparations.

The Bureau maintains radium standards, the primary standard with which all secondary standards are measured and compared being known as No. 6. All the radium bought in the United States is sold over a certificate of its value given by the Bureau of Standards. It is proposed to send one or more of the secondary standards to Madame Curie's laboratory, to the British National Physical Laboratory, and possibly to other European laboratories for recomparison.

The Bureau is coöperating with the research department of the Public Health Service in determining the kind and extent of the effects of the radiation from radioactive materials on the members of the Bureau's staff who handle them.

A charge is made for tests and certificates of radium preparations, the income from which considerably exceeds the appropriation made by Congress for this work, which for the fiscal year 1926 was $10,680.

X-Ray Measurements. The Bureau makes measurements of the protective coefficients or efficiencies of X-ray protective materials, and gives some attention to the physics of radiotherapy. An investigation of the underlying principles of X-rays is just being started and the necessary equipment is being secured.

Atomic Properties. Experimental tests have been in progress for six years in the nature of measurements of the energy required for the different types of atomic disruption (ionization), and the study of the spectra of the resulting radiation. Several methods of exciting radiation have been developed, such as the use of high-frequency current for producing discharges in gas at low pressure, and other researches in this field are being made. The practical application of these investigations, involving an understanding of the structure of atoms and of the nature of collisions between atoms and electrons, is manifested in the development of efficient illuminants and of many important devices involving electron emission, notable examples of which are the Coolidge X-ray tube and the entire field of radio-bulb design.

Photographic Technology. The activities considered under this head include sensitometry or the accurate measurement of the light sensitive qualities of photographic materials; investigation of illumination in photography; photochemical processes; and applied photography.

Sensitometry investigations are being made with the view of developing standardized methods of testing photographic materials. A new sensitometer was developed by the Bureau a few years ago, patented, and dedicated to the public, for measuring the filter factors of color sensitive materials.

An investigation was recently made for a method of deciphering the written and printed matter contained on papers which have been charred, disclosing the fact that good results may be had by the use of photographic plates.

A special camera has been designed for use in the study of electrolysis, to photograph on a continuous strip, the entire outside surface of cast-iron pipe, exhibiting the effects of soil corrosion.

Other work recently done in the field of photographic technology, includes the design of an apparatus for investigating the so-called reciprocity law in photography which states that "the effect of light on a photographic plate (or paper) is proportional to the product of light intensity by exposure time"; the standardization of lamps for sensitometry, and the making of sensitometric tests.

The Bureau has given advice to the Veteran's Bureau on a course of study, laboratory equipment, and laboratory plans for a school of photography conducted by the latter.

Interferometry. Interference of light waves is used to measure small changes of length, and plays an important part in the testing of standards of length; in measuring the changes in such standards with time, temperature, and heat treatment; and in determining the changes in the physical properties, such as expansivity, refractive index, and density of substances. This activity is closely related to that of length standardization considered under the general head of weights and measures.

The extreme sensitivity of interference methods makes it possible to measure the dimensional changes of small samples, such as commercial and optical glass, cast steel, brass, quartz, platinum, etc., so that the expansion of samples one to ten millimeters in length may be determined with an uncertainty of not more than one-half of 1 per cent with the temperature control apparatus available, and measurements may be made in the temperature intervals −150 to +1000 centigrade.

Much attention is given to the work of comparing the precision gauges of manufacturers with the Bureau's standards by the method of interferometry, and several hundred end standards were calibrated for manufacturers of precision gauges in the past few years.

An apparatus has been constructed for ruling line standards, using light waves as the fundamental length standard, scales correct to less than one one-hundred-thousandth of an inch having been ruled.

Measurements have also been made by this method, of the variation of the refractive index and dispersion with temperature on different types of optical glass; also accurate tests of the planeness of optical surfaces.

Coöperation with Other Organizations. An important part of the Bureau's activities in the field of optics consists of furnishing information on scientific and technical subjects in this field, by extensive correspondence and reports, and directly to technical men who visit the Bureau's laboratories.

Members of the staff regularly coöperate in the activities of various scientific and technical societies, such coöperation having been had in recent years with: the American Chemical Society, on refractive index tables for sugar solutions; the American Institute of Graphic Arts, in standardization of process color printing; the American Oil Chemist Society, on the color grading of vegetable oils; the International Astronomical Union, in regard to standard wave lengths; also the American Engineering Standards Committee, the Illuminating Engineering Society, and the Optical Society of America.

The Bureau has also coöperated with the Bureau of Mines in studying questions relating to the optical properties of smoke and dust.

Work in Chemistry. The chemical work of the Bureau is both routine and in the nature of special research. Some of it is done independently, but a large part of it is carried on in connection with other activities. Much of its routine and also its research work consists of tests which are purely chemical in their nature, carried on for other government services, and in some cases for municipal institutions and private parties, such tests as analyses of iron, steel, alloys, cement, rubber oils, paints, varnishes, papers, inks, and other materials. An important part of the Bureau's work in the field of chemistry is the distribution of many standard samples of various materials. The preparation of absolutely pure substances needed in the other work of the Bureau is an important chemical activity; as is also the preparation of specifications for technical materials for government and private industrial and scientific organizations. The chemical work done for other government services amounts to about one hundred thousand dollars in labor and material, which is paid for in part out of appropriations for the Bureau and in part by transfers of funds from such other services. In 1924, the Chemistry Division tested 8956 samples many of which required complicated analyses involving the determination of a number of constituents.

The activities of the Chemistry Division are considered under seven groups, namely, paint, varnish, and bituminous materials; detergents, cements, and corrosion; miscellaneous organic materials; inorganic analysis and standard samples; platinum metals and reagents; electrochemistry; gas chemistry. Other work of a chemical nature is also carried on in connection with other activities of the Bureau.

Special appropriations made annually for "Testing miscellaneous materials," "Structural materials," "Industrial Research," "Public Utilities," and "Standard Materials" are chiefly drawn upon for defraying the expenses of this work.

Paint, Varnish, and Bituminous Materials. The Bureau analyzes and tests a great variety of paint and varnish materials, and bituminous materials for waterproofing and roofing purposes. It prepares specifications for such materials and collects information relative to the service that may be expected from them. The greater part of the work along this line consists of preparing specifications and of making tests of materials submitted by various branches of the government service. Thousands of tests of this character have been made in the past few years. In 1924, 1579 samples of paints and varnishes were tested by the Bureau.

Researches have been made and are in progress concerning the physical properties of paint; the measurement of color of paint; moisture-proofing wood by testing the effect of the preservative process on the properties of wood, and determining the efficiency and durability of various coatings; the nature of shellac wax; acid-proof coatings for concrete surfaces; shingle stains; bituminous paints, varnishes, cements, and similar materials.

The construction of the bituminous bottom of the Lincoln Memorial Pool was practically under the Bureau's supervision, and specifications for and methods of applying waterproof expansion joints for use on the roof of the Lincoln Memorial, the Key Bridge, and the new conduit of the Washington Aqueduct were prepared by the Bureau.

The Bureau furthermore has prepared many United States government standard specifications in the field of chemistry for the Federal Specifications Board; has given consultative advice on particular painting problems to the Shipping Board, the War Department, and other government services. It has coöperated with the Committee on Protective Coatings of the American Society for Testing Materials; with a committee of the American Concrete Institute in preparing specifications for waterproofing materials and in studying waterproofing problems; and with the Paint and Varnish Manufacturers' Association in carrying out work on problems relating to drying oils, color measurements, etc.

Detergents, Cements, and Corrosion. Under this head are grouped the activities in the testing and chemical analysis of detergents, polishes, waxes, non-drying oils, cement, lime, gypsum, clay, sand, coated metals, industrial waters, boiler and fire extinguishing compounds, etc.

Many of these tests are of a routine character, and are made for the purpose of guiding the various government departments in making awards to contractors. In coöperation with the American Specialty Manufacturers' Association, specifications for various kinds of soaps have been made for submission to the Federal Specifications Board and promulgated as government standards.

In coöperation with the Interdepartmental Conference on Chemical Lime, specifications for lime for various uses have been prepared. A method for the determination of quick and hydrated limes has been developed and has been adopted by the Technical Association of the Pulp and Paper Industry, and as a tentative standard, by the American Society for Testing Materials.

In coöperation with the American Society for Testing Materials, "total immersion" tests have been conducted for several years on the corrosion of iron and steel. Researches are being made concerning metallic coatings, such as lead-coated steel, nickel-plated plumbing fixtures, brass and bronze-plated hardware, cadmium-coated steel, etc.

Analyses of waters are being made for the government departments to determine the advisability of purification for industrial use. The Bureau, however, does not test waters as to potability.

Many samples of materials have recently been chemically tested for the Steamboat Inspection Service to determine their fire hazard; tests of naphtha soaps and ritual candles have been made for the Federal Trade Commission; coöperative tests have been made for the American Hotel Association and advice given on the standardization of detergents and other hotel supplies; and advice has been given the National Committee on Prisons and Prison Labor regarding laundry supplies. A process has been developed for the rapid and economical reclamation of gasoline used in dry-cleaning establishments, and the process is now in operation in several plants.

Miscellaneous Organic Materials. Under this group are included the activities in the nature of chemical analysis and investigations of lubricating oils, rubber, paper, textiles, dyes, ink, adhesives, airplane dopes, etc. Thousands of chemical tests and numerous researches are made each year in connection with various organic materials for the government service, for scientific and technical organizations, and for industrial concerns.

An investigation is being carried on for the army and navy, for the purpose of developing a balloon-fabric coating having the best qualities of rubber and of goldbeaters' skin.

The work of the dye laboratory has been developed in two general directions. On the one hand the subject of standard fastness tests for dyes and dyed textiles has been studied. There has been close coöperation with the Research Committee of the American Association of Textile Chemists and colorists in devising tests for general use. Tests for fastness to light and to washing have been of particular interest to the bureau.

On the other hand the subject of standard dyes has been studied. Methods for determining the strength and quality of dyes have been reviewed, with special emphasis on the application of spectrophotometric measurements in this field. This work has involved the preparation of pure dyes and their comparison with commercial dyes by various methods.

Fundamental work on the relation of selective absorption to the constitution of dyes, and of the effect of the solvent, the hydrogen ion concentration, etc., upon absorption spectra is in progress.

The Bureau is annually called upon to test samples of inks, pastes, typewriter ribbons, carbon paper, lubricants, and other articles for various branches of the government services. In 1924, the Bureau tested 346 soaps and polishes and 885 inks and adhesives.

At the request of the Postal Savings Division of the Post Office Department the Bureau has developed a device for finger printing, which is inexpensive, cleanly, and convenient, and whereby the inking of the fingers is avoided.

Many chemical analyses are made of lubricating oils and greases to determine their suitability for service.

Inorganic Analysis and Standard Samples. The activities considered under this head consist of: The development of refined and routine methods of metal and ore analysis; the preparation, standardization, and distribution of standard samples of iron, steel, alloy steels, ferros, brasses, bronzes, bearing metals, melting point metals, ores, cements, and pure chemicals; and the chemical analysis of the metallurgical materials used in the Bureau's research projects, or submitted by other government departments. A special annual appropriation for "Standard Materials" is made to cover the cost of preparation of standard materials.

During the fiscal year 1924, standard analysis samples of metals, ores, and other materials to the number of 4446 were prepared, analyzed, and disposed of, for which fees amounting to over $9000 were collected, and over a thousand tests of metals and ores were made. Whenever samples are issued, certificates are furnished with the same. The chemical samples which are produced by the Bureau and are sent out to chemists throughout the country and the world, are used in checking up the chemists, the reagents which the chemists use, and the analyses of the products which the concerns manufacture. These three checks on the chemical industry and metallurgical operation result in eliminating disputes in distribution and many uncertainties in manufacture. The industry sometimes provides the raw materials out of which the Bureau makes the samples. Chemical analyses of metallurgical products were made for a number of branches of the government, including the War, Navy, Treasury, and Post Office departments, the Shipping Board, Panama Canal, General Supply Committee, Government Printing Office, Bureau of Engraving and Printing, and such branches of the Department of Commerce as the Bureau of Lighthouses and the Steamboat Inspection Service.

The Bureau has recently coöperated with the analysis subcommittee of the Committee for the International Standardization of Zinc in developing methods for the determination of aluminum, bismuth, and tin in spelter and of manganese in zinc ores; at the request of the American Foundrymen's Association it has developed standard methods for the chemical analysis of molding sand; and in connection with the work of the Federal Specifications Board, the Bureau has recommended methods of analysis for materials listed in that board's specifications.

The Bureau at times acts as umpire to settle disputes where analyses have been carried on and the analysts cannot agree. It also aids firms in the standardization of material for which no standards are available.

Electrochemistry. The activities included under electrochemistry are tests and other studies concerning the electrodeposition of metals as in electrotyping and electroplating, the latter covering investigations of zinc, lead, copper, platinum, nickel, silver plating, etc. Work in this field is also performed in connection with other activities, such as measurements of conductivity and hydrogen concentration.

The purposes of the studies upon electrodeposition are: To determine the fundamental principles, especially those which govern the structure and properties of the deposits; to develop methods for the analysis and control of electroplating and electrotyping solutions; and to furnish interested government departments, manufacturers, electroplaters, and others, information and advice concerning the practical application of electrochemistry. The Bureau's experts make frequent visits to plants and deliver lectures to appropriate groups of persons in electroplating and electrotyping, as comparatively few persons have technical knowledge of these subjects. Contracts are also maintained with the industry through the research committee of the American Electroplaters' Society, which meets at the Bureau twice a year.

Recent studies have been made concerning the metal distribution in electrodeposition; the general structure of electrodeposits; the effect of base metal on the structure of copper; and electrolytic alteration of copper map plates. Special attention has been given to nickel deposition.

Gas Chemistry. Under this designation are included the activities relating to methods of purification, analysis, and testing of gases, including fuel and illuminating gas and special gases, such as hydrogen, oxygen, and chlorine.

A large part of the work in this field consists in the development of methods and apparatus for analyzing and testing gases. Some of it is done for other government departments and some to meet recognized needs in industry. Other government departments have been provided with equipment for process control in sulphuric acid, helium, oxygen, and ammonia plants; for gas investigations connected with biological work; for testing the purity of gas in airships; detecting leaks in the gas bags, and computing changes in lifting power with changing conditions of airship operation. An extensive research upon methods of analysis of natural gases, particularly those rich in gasoline, is being carried on in coöperation with the Natural Gas Association of America. Use is being made in this work of an apparatus developed at the Bureau for the analytical separation of gases into their constituents by fractional distillation.

An extensive investigation is being made upon the utilization of fuel gases; and especially upon the safety and efficiency of gas appliances. This work is being done in close coöperation with American Gas Association; the Bureau's part in the program consists principally in the development of testing methods.

The Bureau is equally concerned with the conditions of manufacture and distribution of gas, and their effect upon the service received by the users, and has issued several publications concerned with standards for gas service.

Engineering studies on various subjects related to the production of gases are made when required. A recent investigation made in coöperation with the Army and the Navy was devoted to the various methods for producing hydrogen and led to several interesting developments.

An investigation is in progress upon the fundamental phenomena of the absorption of gases in liquids, including both physical solution and chemical reactions, the purpose of which is to secure complete engineering data by which the performance of any commercial absorbing unit can be computed from a laboratory test upon the gas and liquid to be used. An apparatus has been developed for this investigation by the use of which it is possible to show definitely the course of a reaction lasting not more than one-tenth of a second.

Tests are made upon balloon fabrics, calcium carbide, and other materials purchased by the government or used in connection with scientific investigations and in the testing of which gas analyses or gas measurements are involved.

The Bureau issues, from time to time, summaries of the available knowledge in special branches of gas technology, obtained by a systematic review and indexing of the scientific literature relating to the physical and chemical properties of all important gases, gas analysis, and the methods of producing, separating, purifying, and handling gases for all purposes.

Platinum Metals and Reagents. This work consists of studying the methods of testing reagents and apparatus to be used in chemical analysis, including study of chemical glassware, porcelain, platinum, and platinum substitutes.

The studies in this field concerning the platinum metals cover the methods of separation, of purification, and of analysis, the routine preparation of pure materials, and the analysis of platinum-bearing materials. Of these, the study of methods of analysis of crude platinum and platinum alloys has recently occupied much of the Bureau's attention.

The determination of iridium in platinum alloys is regarded as very important, as iridium alloys are extensively used in a number of industries. Work has been done to determine the limitations of the Deville-Stas method, which although first used over fifty years ago is still the most reliable method known. A large number of analyses have been made on specially prepared alloys in order to determine the accuracy of the method, the effect of the presence of other metals in the alloys, and the effect of variations over a wide range in the details of procedure.

Work on the analysis of platinum ore, which was recently undertaken, involves the separation of the six platinum metals besides copper, silver, gold, and iron, and the determination of those elements of commercial value, usually platinum, iridium, rhodium, palladium, and gold. A scheme has been outlined which has as its principal object the attainment of greater accuracy in these determinations than is possible with the methods now in use without unduly adding to the time required for a commercial analysis.

A considerable amount of pure platinum has been prepared by the Bureau for use in the various investigations in progress, and in a few cases platinum ware has been issued in small quantities to outside laboratories where the highest purity was essential. Other work on purification consists of the routine preparation of the various metals needed by the Bureau.

As rhodium has been increasing in scientific and industrial importance in recent years, a systematic study of the quantitative separation of rhodium from platinum has been undertaken. Work is also being done on the purification of rhodium.

The Bureau examines all reagent chemicals purchased, and is endeavoring to improve the methods used in testing reagents.

With coöperation of a maker of glass apparatus, the Bureau has recently given some attention to the improvement of glass analytical funnels.

A bibliography of the metals of the platinum group has been prepared, which supplements and brings to date a bibliography published by the Geological Survey, which was completed through 1917.

Coöperation with other Organizations. In carrying on the work in chemistry, the Bureau coöperated with various technical societies and other organizations engaged in chemical research, including, among others, the American Society for Testing Materials, American Chemical Society, American Engineering Standards Committee, American Gas Association, the American Association of Textile Chemists and Colorists, Federal Specifications Board, American Concrete Institute, American Electroplaters' Society, Paint and Varnish Manufacturers' Association, Interdepartmental Conference on Chemical Lime, Natural Gas Association, and American Foundrymen's Association.

Mechanics and Sound. Under mechanics and sound are grouped investigations relating to mechanics, sound and the properties of matter, including engineering mechanics, hydrodynamics, aerodynamics, and aeronautic instrument and engineering instrument research; embracing the determination of physical constants, the standardization of mechanical appliances, the testing of structural and fabricated materials, the investigation of the soundproofing qualities of building materials, the analysis and correction of acoustical defects in auditoriums, the development of radio-acoustic ranging methods, time-signaling apparatus, the study of elastic fatigue and the elastic properties of diaphragms and springs, the development and testing of aircraft and engineering instruments, ballistics, wind tunnel tests and research, orifice meter investigations, walkway research, and the development and standardization of plumbing systems, builders hardware and elevator safety interlocks.

A special appropriation is annually made by Congress for "Standardization of mechanical appliances."

Engineering Instruments and Appliances. An important activity is the study of the theory, characteristics, and limitations of engineering instruments and mechanical appliances; their development and improvement; the development and improvement of methods of calibration; the formulation of standards of their performance; and the investigation of new appliances of engineering importance.

Over a thousand tests were made in the past two years of current meters, pressure gauges, anemometers, speedometers, miscellaneous instruments, radiator valves, fire extinguishers, and other mechanical appliances.

Among the important researches made in recent years in this field was an investigation of the safety devices used on hydrogen cylinders, to safeguard them against explosion when extraordinary pressure is developed within the cylinder. This was undertaken at the request of the Chief of the Air Service of the Army. It resulted in the development of an improved safety device.

About three-fourths of the fatal elevator accidents occur as a result of the door being open when the car is not there or of the car being in motion while the door is open. To prevent such accidents, interlocks are used. At the request of the city of Baltimore, the Bureau of Standards has been giving considerable attention to the investigation of the reliability of existing interlocking devices, with the aim of developing a well-designed and reliable device which would eliminate such accidents. The Bureau has developed an effective laboratory service test of such interlocks which has been adopted by the city of Baltimore as part of its elevator code, which code requires all elevator interlocks to be tested by this method before permits are granted. The performance requirements developed for interlocking devices have also been included in specifications used by the Supervising Architect of the Treasury. As a result of this work, manufacturers have redesigned their interlocks to correct weaknesses which were developed, and the safety and reliability of elevator interlocking devices have been greatly advanced.

At the request of the Supervising Architect of the Treasury Department, a series of performance tests was recently made of all thermostatic valves on radiators presented to that office for its approval for use in public buildings. The data resulting from such tests are employed by that and other government offices.

In coöperation with interested manufacturers, the Bureau has prepared specifications for builders hardware, which will be used not only by the government departments but probably also to a great extent in the hardware industry.

Tests and investigations have also been made at the request of the Steamboat Inspection Service, of hand chemical fire extinguishers for the guidance of the Board of Supervising Inspectors.

An investigation of the performance of commercial types of odometers has been made at the request of the Motor Transport Corps of the Army. A machine for approximating the conditions of road service has been constructed, and tests of commercial devices are being made.

The Bureau maintains an hydraulic laboratory, designed and equipped especially for use in the calibration of water-current meters or instruments used in the measurement of the quantity of water flowing in rivers and other open channels. Several hundred such meters are tested each year.

Aeronautic Instruments. The testing, research, and development work on aeronautic instruments is carried on mainly for the Army, the Navy, and the National Advisory Committee for Aeronautics, with funds furnished by these organizations. The Bureau has also, to a more limited extent, undertaken such work for other government departments.

The Bureau tests, standardizes, prepares specifications for, and develops aeronautic instruments, such as altitude, rate-of-climb, power-plant, and air-speed instruments, special instruments for lighter-than-air craft, navigating instruments, surveying and engineering aneroid barometers, special mercurial barometers, etc. It also conducts experimental investigations and researches concerning the fundamental physical principles involved in such instrument development and determines altitudes for record flights.

Investigations and researches now carried on or recently completed cover: Investigation of Bourdon tubes, of metallic and of non-metallic diaphragms, barometric syphon diaphragms, gasoline flow meters, aircraft sextants, bimetallic bars for temperature compensation, theory of rate-of-climb indicators, methods of reducing astronomical observations in aerial navigation, and the theory of astronomical position finding and its application to the navigation of aircraft.

The following aeronautic instruments have recently been constructed or are being developed by the Bureau: Ground speed and drift indicator, distant indicating tachometer, turn indicator, electric turn meter, horizontal angle indicator, precision barometer, precision altimeter, precision barograph, temperature-compensated altimeter, temperature-compensated thermo-barograph, open-scale landing altimeters, surveying aneroid, a new mercurial altitude barometer design, mechanical statoscope, improved mechanical rate-of-climb indicator, improved liquid rate-of-fire indicator, combined statoscopes and rate-of-climb-indicators, high-speed air-speed indicators, suspended head electric air-speed indicators, gas pressure alarm for a rigid dirigible, ballonet volume indicator, fabric tension meter, aircraft compasses, and a submarine mine depth recording instrument. A considerable number of these instruments were especially constructed for use on the navy airship, the Shenandoah.

Flight-history tests of barographs have been made, in which the factors of time, barometric pressure, and instrument temperature are made to repeat in the laboratory the conditions of the actual flight. Many flight tests are made by members of the staff in connection with the development and study of aeronautic instruments, in various types of aircraft furnished by the army, the navy, and the National Advisory Committee for Aeronautics.

Aerodynamical Physics. The investigations in aerodynamics relate chiefly to the measurement of the resistance of the air to the motion of bodies, including determination of the magnitude, direction, and point of application of the resultant force, its relation to the relative speed, and the force distribution over the surface of the body. These studies include the measurement of forces and moments of airfoils, airplane and airship models, aircraft bombs and bomb models; measurement of the damping of oscillations of bombs, airship models, etc.; measurement of the distribution of pressure over airship hulls, airship fins, projectiles, etc.; and measurement of wind pressure on structures; also the calibration of instruments for use in air-streams of speed ranging from 15 to 150 miles per hour.

The work in aerodynamical physics is carried on largely with the coöperation and financial assistance of the Engineering Division of the Air Service and the Ordnance Department of the army, and the National Advisory Committee for Aeronautics. For carrying out this work the Bureau is equipped with three wind tunnels, differing in size and speed ranges for adaptation to a great variety of work.

At the request of the engineering division of the Army Air Service an extensive program was recently carried out for the study of forces acting on airship models and the distribution of pressure on airship hulls, to aid in designing a semi-rigid airship developed by that service.

Attention has also been given to the determination of the merits of various devices for shielding airships when landing and leaving their hangars.

A comprehensive investigation in aerial bombs has been occupying the attention of the Bureau for several years, a particular study having been made of the forces acting on models equipped with various forms of fins. A satisfactory method for estimating the fin surfaces required to insure sufficient stability has been developed.

Resistance measurements of models of projectiles and bombs have been carried on for several years for the Ordnance Department of the army, using a high-speed air stream supplied by large centrifugal compressors at the Lynn Works of the General Electric Company.

In coöperation with the National Advisory Committee for Aeronautics, measurements have been made on the aerodynamical characteristics of airfoils at high speeds for the purpose of obtaining data for use in designing airplane propellers. The investigation was made at the Lynne Works of the General Electric Company, where large centrifugal compressors were available for a high-speed air stream.

At the request of the American Society of Heating and Ventilating Engineers, researches have been made on problems involved in roof ventilation. A preliminary report issued a few years ago resulted in the submission by manufacturers, for testing, of many samples of ventilators used in connection with natural systems of ventilation for factories, school buildings, etc. The investigations cover the principles involved in producing an exhaust by means of a wind normal to the axis of the ventilator, the results of which have led to a few simple designs, some of which have been adopted by manufacturers.

Engineering Mechanics. In the field of structural and engineering materials, measurements are made of the resistance of such materials, especially of metals and wood when fabricated into structural units, under tensile, compressive, and tortional tests; the fatigue and impact resistance of these materials, as well as their hardness, are studied; new types of testing apparatus are designed with the view of improving testing methods; the properties of new materials are examined to determine their suitability for use by the government and by American industry; alloys of aluminum having low weight are examined because of their importance in aircraft construction; and engineering structures are designed and tested to determine the construction most suitable for a given purpose.

During the fiscal year 1924, over a thousand tests were made of steel, iron, other metals and alloys, enamels for sheet metals, rope of wire, manila and sisal, large H columns, structural members (Delaware River bridge), and other structural engineering work and materials.

In connection with the design of the new suspension bridge to span the Delaware River from Philadelphia to Camden, the Delaware River Bridge Joint Commission recently submitted for test fourteen special column sections of the type to be used in that construction. In order to make these tests, a new form of electrical strain gauge was designed and constructed at the Bureau, which gives readings showing instantaneously the value of stresses in complicated structures. The tests resulted in the furnishing of valuable information to the Commission.

An investigation was recently undertaken by the Bureau in coöperation with the American Railway Association and the American Bureau of Welding, to determine the tensile strength, electrical conductivity, and impact resistance of various types of welded rail joints. In making these tests, special grips for use in the large testing machines were designed.

In coöperation with the American Bureau of Welding an investigation was recently completed on the strength of welded pressure vessels, the results being used by the Boiler Code Committee of the American Society of Mechanical Engineers in preparing a safety code for this class of construction.

Among the other tests and researches recently made concerning structural and engineering materials were: Tests of telemeters for use in testing girders for an airship and for the above-mentioned column sections of the proposed Delaware River bridge; tests of tensile, compressive and shearing strengths, ductility, modulus of electricity, and other related properties of pure metals, their alloys, and of wood; tests of reenforced concrete floor of the Arlington Building (Veteran's Bureau); tests of fatigue of woods and metals, most of the work being on sheet duralumin for the Bureau of Aeronautics of the Navy Department; hydrostatic and strain gauge measurements on welded and riveted tanks; tests of brick walls made in coöperation with the Common Brick Manufacturers' Association; investigation of the strength of corrugated zinc roofing in coöperation with the Zinc Institute of New York; tests of crinkling stresses in steel tubing; tests to observe the behavior of riveted joints under working stresses, made for the Bureau of Construction and Repair of the Navy Department; tests of the strength of various members of the Airship Shenandoah; tests of riveted and welded joints, made for the American Bridge Company; and investigation of a process for seasoning wood.

New apparatus has recently been developed for dead-weight calibration of testing machines; also improved apparatus for brick testing. The methods of testing hardness of metals have been systematized, and the calibrations of the hardness machines have been put on a systematic and uniform basis for the country.

Federal specifications for wire rope were recently prepared in coöperation with representatives of other government departments and of manufacturers of wire rope.

A bibliography of technical publications on riveted joints was recently prepared, which includes references to English, French, and German activities.

An extended investigation on the strength of masonry walls is being carried on covering eight-and-ten-inch walls constructed from common and medium brick, sand-lime brick, and building tile. Three kinds of mortar are being tested, including lime mortar, cement mortar, and a mixture of lime and cement in equal parts. Test walls are constructed, allowed to age sixty days, and then are loaded to failure in the ten-million-pound testing machine. The results will provide definite information regarding loads which may safely be carried by different types of wall construction.

In coöperation with the Bureau of Construction and Repair of the Navy Department, a study of stress distribution and elastic action in riveted ship-plate joints have been undertaken.

Special Investigations. Special investigations in mechanics and properties of matter and in the standardization of mechanical appliances, have also been undertaken at the Bureau. The researches of this character undertaken in recent years cover: High pressure steam-heating lines, rate of exhaustion of closed tanks, jet propulsion of airplanes, leakage through clearance spaces, relative wearing value of ball-bearing and steel bushed bronze butts, earth inductor compass, precision weighing of large crystals, gravitational constant, gyroscopical stabilization, dimensional theory, orifice meter research, carrying capacity of soil stacks, plumbing traps and standardization of machine tools and builders' hardware.

Sound Measurement. The Bureau's activities in the field of sound measurement cover sound intensity measurements, sound sources, sound receivers, ballistic measurements, oscillography, chronography, and frequency standardization. A special appropriation for " Sound investigation " is made annually, by Congress.

In response to inquiries from manufacturers of building materials, builders, architects, building owners, and others, indicating a pressing need for information concerning the sound-transmitting and sound absorbing properties of building materials, the Bureau is giving much attention to this subject.

A comprehensive investigation is being made of the types of wall and floor construction which will prevent sound from being transmitted appreciably from one room to another. This work is being carried on in coöperation with the National Lime Association and the National Gypsum Association.

As the experimental determination of the sound transmission and sound absorbing properties of materials involves the measurement of relative sound intensities, a method for making such measurements with great precision has been developed at the Bureau. This involves the use of an electro-mechanical sound receiver, an amplifier and a galvanometer. This measurement of relative sound intensities has involved the development of an instrument for measuring the electrical power consumed by an electromechanical sound-producing instrument. A sound chamber has been constructed for use in determining the acoustic qualities of building materials.

The Bureau makes analyses of faulty rooms and auditoriums, including school assembly rooms and offices, and suggests improvements, also analyses of building plans to forestall such faults in acoustic qualities.

In coöperation with the Bureau of Construction and Repair of the Navy Department the Bureau is making a series of experiments on the sound-transmission characteristics of voice tubes and voice-tube fittings.

The Bureau is coöperating with the Bureau of Lighthouses and the Coast and Geodetic Survey in the solution of problems involving elaborate investigational research, such as developing improved methods in radio and sound signaling devices with the view of decreasing the operating cost of aids to navigation, such as reducing the number of lighthouses. A procedure was recently worked out for determining at any moment, the position of a ship with reference to known shore points, by means of sound signals through the water from the ship and radio signals from the surveyed shore stations when the sound signal arrives. This is especially useful in surveying operations during foggy weather.

Instruments have recently been developed by the Bureau and successfully used by the Coast and Geodetic Survey for recording radio time signals in connection with precise longitude determinations. With a set of these instruments time signals from Annapolis have been successfully recorded in Alaska and longitude determinations have been made.

In coöperation with the technical staff, Army Ordnance, and the Bureau of Ordnance, Navy Department, considerable work has been done in recent years in the development of various types of apparatus for ballistic measurements.

Investigation and Testing of Structural Materials. This group of activities, more than any other, brings the Bureau into close coöperative contact with the manufacturing industries of the country. It includes the testing and study of structural and engineering materials, cement, concrete, stone, lime, gypsum, and sand-lime brick. The Bureau studies the uses of these materials, the processes by which they are manufactured, the improvement of the present method and the development of new methods of testing them and the establishment of standards covering their use.

The expenditures for these activities are mainly met out of the special appropriations made annually for "Testing structural materials."

About fifty important societies and industrial group organizations coöperated with the Bureau in this field of activities. In the majority of cases the connection with these organizations was through technical committees appointed by them, to advise and consult with the Bureau in regard to problems in which they were interested.

Cement, Concrete, Concrete Materials, and Building Stone. The Bureau investigates and tests cement, concrete, concrete materials, and building stone to determine their quality for construction purposes; develops new methods of and improved apparatus for such testing; prepares specifications covering cement and concrete construction; and develops new uses for cement products, and distributes knowledge concerning their use, and the design and fabrication of concrete structures. It also acts as a testing laboratory for cement used in the government's construction work, nearly all the cement manufactured for the government being inspected by the Bureau. During the year 1924, 1,293,158 barrels of cement, valued at over three million dollars, were tested for the government by the Bureau.

Investigations and researches are made concerning the constitution of Portland cement, plastic magnesia, stucco and plaster, reenforced concrete, durability of concrete in alkali and sea water, building stone, volume changes in concrete, fineness, concrete tanks for oil storage, and general concrete investigations. Experiments are being made which, it is expected, may demonstrate that Portland cements as now made can be accelerated in their hardening by the addition of certain cheap materials.

Inspections and tests of cement include sampling, testing, packing, and shipping cement purchased by the several departments of the government, for which purpose laboratories are maintained at Washington, Northampton (Pa.), Denver, and San Francisco.

More intensive work is needed on the characteristics, properties, and specifications for cement and concrete in order to secure permanence in concrete structures. Concrete materials are used in such enormous quantities that it is in the public interest to secure the fundamental information so much needed for their improvement in manufacture and application in roads, buildings, bridges, and other structures. More knowledge is needed of the conditions under which deterioration has occurred and for the proper diagnosis and security.

The Bureau has arranged with a group of five men, who are leaders in their various professions and industries, to take up a comprehensive study of the subject of cement, the study to be centered in the Bureau of Standards. They are undertaking the investigation for the purpose of centralizing in the Bureau of Standards the leadership of all scientific investigations in behalf of private and semi-public organizations, and to bring about the adoption of some thoroughly worked out designs and formulæ for mixtures under varying conditions in different climates and for different purposes. This will result in a vast saving and in a more accurate and intelligent use of this material.

The Bureau is engaged upon a study of the constitution of Portland cement, in coöperation with the Portland Cement Association, the purpose being to determine the effect of burning and composition of the properties of finished cement. This study will cover a period of several years.

An investigation is being carried on at a number of places, concerning the durability of concrete in alkali soils by the installation of experimental drains. Examinations have also been made of concrete specimens installed by the Portland Cement Association at other points.

In coöperation with the Portland Cement Association, the Joint Committee on Standard Specifications for Concrete and Reenforced Concrete, and a Committee of concrete contractors, a thorough field test was recently carried out on two major building operations to establish a means of introducing into practice some of the improvements in the technique of concrete making which recent researches have indicated to be desirable.

Weathering tests are in progress on various typical building stones, the work thus far done being chiefly confined to the weather-resisting qualities of limestone and sandstone. Frost action tests are also being made, those on limestone being carried to the point of disintegration.

Other tests and researches are in progress or were recently made concerning: Inundation method of measuring sand; disintegration of concrete due to altered feldspar aggregate; workability of concrete mixtures; durability of sewer pipe; cement stucco; concrete house construction; tests of reenforced gypsum roof slab; bond tests of Dudley deformed bars and plain round bars; exposure tests on colorless waterproofiing materials; tests of sieves and molding sands for the joint committee on molding sand research of the National Research Council; elastic pointing and calking materials; and discoloration of stone masonry.

The Bureau has developed an improved flow table for measuring consistency of concrete, and an air analysis for determining fineness of Portland cement and other materials.

The Bureau has given much attention to coöperative work with the Joint Committee on Standard Specifications for Concrete and Reenforced Concrete, and on the Special Committee on Reenforcing Steel, functioning under the auspices of the American Society for Testing Materials. A number of new and revised municipal building codes have been submitted to the Bureau for criticism in this connection.

Attention is being given to the qualities of hollow tile used in connection with reenforced concrete for floor slabs, with the view of developing a theory of design that is now much needed. Studies are also being made at the suggestion of the brick industry, of the properties of brick walls.

As a result of laboratory testing of a large number of commercial composition floorings, a tentative specification was recently drawn up which was presented to and adopted by the National Association of Oxychloride Cement Manufacturers.

The Bureau has prepared and keeps on hand for issue, standard fineness samples of cement for checking up No. 200 sieves. They are supplied in two degrees of fineness and are issued in sealed glass jars, each jar containing about 160 grams, enough for three 50-gram sieve tests. A price of 50 cents, sufficient to cover the cost of preparation, is charged for each jar.

Lime, Gypsum and Sand-Lime Brick. The Bureau's activities in dealing with these materials consist of the development of standards, the improvement of manufacturing processes to produce better or cheaper materials, and the collection and dissemination of knowledge which will lead to their more efficient use. Special attention has been given to the development of new test methods and the obtaining of test data for use in the preparation of standard specifications. In furtherance of this work a representative of the Bureau occasionally visits manufacturing plants in order to keep in touch with the developments of the industry.

Researches are in progress or were recently completed concerning the use of hydrated lime in Portland cement mortar; improvement of plasticity of hydrated lime; effect of addition of hydrated lime on the properties of concrete; use of lime in the chemical industries; strength of bond between mortar and sand-lime brick; causes of unsoundness of lime plasters; physical properties of calcined gypsum products; acoustics of wall plaster;

effect of moisture on set gypsum plaster; grading of sand for sand-lime brick; utilization of old plaster molds; improvement of gypsum block; adhesion of gypsum plaster to concrete; and how to make lime set quickly.

In order to indicate to the users of lime in the chemical industries the kinds of lime that are available for their particular needs, and to the makers the kinds of lime that are needed, the Bureau has undertaken to prepare a series of specifications covering the different kinds of lime required by the large users. To take advantage of the information possessed by other branches of the government an Interdepartmental Conference on Chemical Lime was organized to prepare these specifications. Prior to its publication each specification is submitted for criticism to both makers and users of the particular kind of lime.

In coöperation with the National Lime Association, the Contracting Plasterers' International Association, and the International Plasterers' Union, an investigation was recently made to determine the cause of unsoundness of lime plaster known as "popping." It was found that "popping" was caused by overburned lime or by lime burned during hydration.

The Bureau, in coöperation with the National Lime Association, has recently made a study of a method to produce the quick setting of lime, so that this material can compete on a more nearly equal basis with gypsum. It has been found that a mixture of ground quicklime and hydrated lime can be successfully made into building blocks at the factory, but the mixture will not keep well when shipped.

The Bureau has for some time been at work on a method of improving the plasticity of hydrated lime, special attention having recently been given to the development of a process for producing "finishing" hydrate as the original output instead of "masons'" hydrate. The Bureau is investigating the manufacture of gypsum into the large variety of commodities in which it now appears on the market, the service obtained from these commodities, and the effect of composition of the original gypsum and the method of manufacture on the properties of the finished product.

Study of Miscellaneous Materials. Under this head are included studies of the physical and chemical properties of leather, rubber, textiles, and paper, with the view of improving the standard for those commodities.

Leather. The activities of the Bureau with regard to leather consist of the investigation and testing of leather and leather goods in order to determine the physical and chemical properties and the relative durability of different kinds. These data are essential in preparing standards of quality. The Bureau is engaged upon problems concerning the wearing qualities of sole-leather, the proper tanning of leather, the possibilty of using synthetic tanning materials, and the development of testing methods and the formulation of particular specifications for leather products.

The Bureau has recently completed a comprehensive investigation to determine the comparative durability and utility value of chrome-tanned sole-leather and vegetable-tanned sole-leather, resulting in the conclusion that chrome sole-leather will wear approximately twice as long as vegetable sole-leather per unit of thickness, but that in order to secure firmness and water-resisting properties comparable to that of vegetable-tanned leather, the wearing quality of the chrome leather must be sacrificed to some extent.

Considerable attention is being given to the study of synthetic tanning materials, what these materials are, how they might readily be produced in this country, and the quality of the leather which might be obtained from their use. The Bureau has obtained some excellent leathers, possessing good color, firmness, flexibility, and great strength, but lacking in the fullness and weight required of certain heavy leathers. The Bureau has also undertaken an investigation on the production of synthetic tanning materials from coal-tar products, involving actual manufacture and development processes, with reference to methods of sulphonating, condensing, mixing, and diluting.

Experiments are being made with hog skins and sheep skins, and it is believed, as a result of these tests, that hog skins and sheep skins may be brought into general use for shoe uppers, thereby presenting larger sources of raw skins in the case of hogs and a new use for sheep skins not seriously considered before.

The Bureau recently rendered assistance to the Public Health Service in connection with the development of standard shoes for letter carriers for both winter and summer wear, involving tests for quality of the leather used, study of the construction of the shoes, and actual service tests. Similar studies were made on shoes for the New York police department, and on shoes made in one of the state prisons, the latter being the result of a contract made with the National Committee on Prisons and Prison Labor.

Tests made with samples of specially prepared colon leather, have demonstrated it to be satisfactory for use as slack diaphrams in certain aeronautic instruments.

Other researches made in this line, relate to the properties of and specifications for leather belting, in coöperation with the Federal Specifications Board; the properties of, and specifications for upholstery leather; chemical methods of, and specifications for lace leather; properties of shark leather; and leather substitutes.

Rubber. The Bureau is very largely concerned with the development of standard specifications for materials purchased by the various government departments, involving a large amount of experimental work and many routine tests and analyses. Other tests and researches concerning the properties, durability, activity, etc., of rubber and certain rubber goods, and the sources of crude rubber, the reclaiming of rubber, and the effect of sulphur on rubber, are also made.

In coöperation with the Federal Specifications Board researches have recently been made, and forty-five specifications for different rubber products have been prepared. These include pneumatic tires, cushion tires, inner tubes, jar rings, fire and other rubber hose, rubber tubing, rubber bands, and hospital supplies.

At the request of the Department of Agriculture an investigation was made to determine the reason for the rapid deterioration of rubber used in milking machines. It was found that this trouble could be eliminated by the thorough removal of the butterfat before sterilization.

The Bureau maintains an endurance tire-testing machine, on which tests can be made of tires under conditions comparable with road service. In making such tests it has the coöperation of various other government departments, particularly the Post Office Department, in checking up the laboratory results with road tests. Test conditions have been established and have been verified by tests on tires from representative manufacturers. A number of manufacturers have availed themselves of the special tire testing equipment to determine the effect of new features in the design of tires. This has been carried out on a dynamometer, with which it is possible to determine the energy absorbed by the tire during the test.

At the request of the Signal Corps, an investigation of insulated wire is being carried on. The different kinds of rubber, gutta-percha, balata, etc., are being studied in order to determine the best materials for insulation purposes consistent with cost and availability. Investigations have also been made on insulating tape.

With the view of maintaining proper standards for rubber goods, advances in the methods of preparing rubbers from the latex are being followed, and experiments conducted with these specially prepared rubbers have shown surprising results in the way of possible increases in tensile strength.

A study is being made of the various methods of reclaiming rubber, with the object of developing more efficient production processes and better quality of product. Studies are being made of the possibility of using reclaimed rubber to a greater degree.

An important activity is the analysis of rubber goods representing material purchased by various government departments. Methods of analysis proposed by the Bureau and adopted by the American Chemical Society, and substantially by the American Society for Testing Materials, have been submitted, for approval, to the Federal Specifications Board. It is the Bureau's policy to coöperate to the full extent with manufacturers with the view of having the requirements of specifications conform in every way to the best manufacturing practice.

Textiles. The activities with regard to the textile industry relate to the qualities which determine the value of the textiles to the ultimate consumer, such as the development of accurate methods for measuring resistance to abrasion, thermal conductivity, durability against perspiration, etc. They cover the study of the preparation, grading, and sampling of the raw fibre; study of manufacturing processes; the effect of various processes on the finished product; the economics of varieties and design, conditions and tolerances; study of efficient application in present uses and new uses; wearing qualities of textiles; heat-retaining properties of fabrics; methods of chemical, physical and microscopic testing;

and handling of finished product, such as laundering, pressing, storing, and cleansing.

The Bureau aims to be of assistance to the textile industry through the introduction of research and standardization, and through assistance in obtaining fundamental data upon which to base standardization. Along these lines the textile industry has been successfully approached and one main committee, known as the main advisory committee of the Bureau of Standards on research and standardization, has been formed. The following associations have appointed advisory committees to work with the Bureau on subjects of particular interest to them: The National Association of Wool Manufacturers; the American Association of Woolen and Worsted Manufacturers and the National Association of Woolen and Worsted Spinners have appointed a joint committee; the National Association of Cotton Manufacturers and the American Cotton Manufacturers' Association have also appointed a joint committee; National Association of Hosiery and Underwear Manufacturers; Cordage Institute; Cotton Duck Association; Silk Association of America; National Association of Finishers of Cotton Fibres; Association of Manufacturers of Window Shades and Shade Cloth; National Tent and Awning Manufacturers Association; Interstate Cotton Seed Crushers' Association; American Association of Wool Blanket Manufacturers; and National Committee on Prisons and Prison Labor.

A large part of the textile work consists of researches with the view of preparing specifications for, and standardizing textile materials and fabrics. Much attention is given to the testing of samples, over ten thousand textile samples having been tested in the past two years.

When specifications for textiles were originally prepared by the government departments very little investigational work was done. Now the Bureau makes a thorough study of each of the fabrics under consideration, especially with regard to heat-resisting and wearing qualities, with the view of forming an efficient specification board primarily on commercial materials. A survey of all government specifications for textile materials, with the coöperation of the Federal Specification Board, shows that over 950 specifications have been drawn up, covering over 1500 separate materials. A complete file is being collected for the consideration of each of the materials as they are taken up by the textile committee of the board. Committees representing the various branches of the textile manufacturing industry are being organized to expedite the handling of this work. From the comments, criticisms, and collective data thus obtained, tentative specifications are prepared, and after approval by the textile committee and the commercial committee, they are submitted to the board for adoption and promulgation.

At the request of the Navy Department a series of tests was made on the outer cover cloth of large airships to obtain fundamental data on the relations of the stresses in the covering. Para silks are being studied as well as the possibility of developing substitutes for silks for this usage.

Surveys have been made at the request of the Post Office Department to obtain data which would enable that department to secure the most suitable material for conveyor belts. As a result of the Bureau's recommendations, specifications covering rubberized fabric and stitched canvas belts were drawn up by the Post Office Department in coöperation with the Bureau.

In coöperation with the Bureau of Mines, work is being carried on in the preparation of specifications for brattice cloth, for its application and for testing the material.

At the request of the Veterans' Bureau an appraisal has been made by the Bureau of Standards of a large quantity of textiles to be disposed of by the former, the items ranging from cheesecloth to heavy duck, bandages, absorbent cotton, aprons, sheeting, and blankets.

The Bureau in coöperation with the War Department is making a survey of the present available sandbag containers with the view of substituting cotton for jute sandbags and the possibility of utilizing proper yarns and textile fibers.

At the request of a manufacturer of magnet wire, a committee was formed composed of electric wire manufacturers and cotton yarn dealers for the purpose of drawing up, in coöperation with the Bureau, a standard method of testing the physical properties of electric cotton yarn.

The Bureau, in response to requests from growers of Arizona Egyptian cotton, usually known as Pima cotton, has taken up an investigation as to the use that can be made of this material. Service tests of mail bags made of this cotton are being made by the Post Office Department.

Investigations have also been made of the question of proper treatment with respect to humidity in textiles in the process of their manufacture; of the question of dyeing textiles; of the workability of apparatus used to determine the abrasive qualities of fabrics; of the physical properties of fish lines; and to obtain standard methods of testing fastness of colors to light, washing, and other factors, the last being undertaken at the request of the American Association of Textile Chemists and Colorists.

The Bureau has recently completed a study of a design of apparatus for, and the most suitable method of testing the comforting value of fabrics.

Paper. The Bureau studies and develops methods of testing paper; investigates paper-making materials; produces experimentally special types of paper; studies paper-making processes; develops standards and specifications for papers; and tests paper, both for the government and for the public. It makes several thousand tests of paper samples each year.

Researches are in progress or have recently been completed concerning the thickness and color, and the bursting, breaking and tensile strength, brittleness, and waterproof and sizing qualities of paper; the effect of humidity on paper; anti-tarnish paper for wrapping metal goods; flax-straw paper; the use of rubber latex in paper; methods of fibre analysis; chemical hydration of pulp; white water waste and its recovery; photomicrography of paper; glue for coating paper; flax-straw paper; proposed standard substance for paper; standardization of paper; sheet sizes of paper; classification and definitions of paper; case lining paper; condense paper; and barograph and siphon cable paper.

Much attention is being devoted to the possible reduction of manufacturing costs to offset, in a measure, the growing scarcity of raw materials. With this in view studies have been made of the question of clay fillers in paper and the use of American and foreign clays, with the result that American clays have been found in general to be as satisfactory as foreign clays, except that the color and the amount of grit favor the foreign clay. The matter of finding a substitute, such as glue, for a food-product, casein, is also being studied.

Experiments are being made to take the glare out of window envelopes, in order to ease the strain on the eyes of postal clerks.

The investigation concerning rubber latex in paper was made for the paper division of the Bureau of Foreign and Domestic Commerce, and covered tests of the quality in regard to strength, finish, filler retention, etc. Another study, for the transportation division of the same bureau, was made of the technical requirements of case-lining paper for overseas equipment.

The Bureau, in coöperation with representatives of manufacturers and users of paper, has for some time been giving much attention to the standardization of paper as to sampling, testing, and tolerances. A report was made proposing standard methods of sampling paper, standard procedure for certain tests on paper, and recommending definite tolerances. A recommendation has also been made by one of the committees, for the adoption of a standard substance or weight basis for all paper in place of the numerous bases now in use for the different grades or classes. For several years committees have been coöperating on the problem of the sheet sizes of paper with the view of simplifying and reducing the number of sizes made and kept on hand by merchants, surveys having been made of the field, including paper sizes for general commercial printing, for books and magazines, for catalogues and directories, and for bond, writing, and ledger paper forms.

The Bureau has given much assistance to various government offices in the development of proper specifications for the purchase of paper, notably the General Supply Committee, the Post Office Department and the Government Printing Office.

Work in Metallurgy. The metallurgical work consists of research, investigation, and methods of testing as related to metals and alloys. The study of built-up metal structures and of the processes of extraction of metals from their ores does not fall within the scope of this group of activities. It broadly comprises all means for the control of physical properties of metallic materials, including the production of metals and alloys, both of the highest attainable purity and of commercial grades; the preparation and study of auxiliary metallurgical products such as slags, "deoxidizers," molding sands, refractories, and "gases in metals"; the design and development of apparatus, instruments, and manufacturing appliances for metallurgical processes, research, and testing; the formulation and maintenance of standards and specifications of interest to metallurgists; the determination of metallurgical constants and properties; the investigation of the performance of manufacturing units; the determination of the causes of failure of metals, together with the study of the improvement of metal products; and the development of economical metal substitutes. The Bureau has equipment for metallographic examinations of metals such as microscopic analyses, including determinations of constitution, structure, and causes of failure; for X-ray spectrographic crystal analysis; for thermal analyses, including determination of heating and cooling curves for location of critical points; for the various heat treatments, such as annealing, quenching, cementation, and tempering; for various operations for the hot and cold working of metals, such as forging, rolling, drawing and welding, and for miscellaneous mechanical tests at ordinary and high temperatures; for the usual foundry operations of molding and casting ferrous and non-ferrous metals; and for other metallurgical processes, such as production of pure metals by electrodeposition and other means, and determination of gases in metals.

The problems studied are often suggested by other government departments, by representatives of the metallurgical industries, or by technical societies. Many problems as to the causes for failure in service of metallical materials, the selection of suitable material for a given service, and other metallurgical problems requiring experimental study, are brought to the Bureau by other government departments. This phase of the work is steadily increasing in amount and is considered one of the chief functions of the metallurgical Division of the Bureau. Such problems are brought in by various branches of the navy and the army, the Panama Canal, the Emergency Fleet Corporation, State Department, Post Office Department, Department of Agriculture, Veterans' Bureau, National Advisory Committe for Aeronautics, Federal Trade Commission, Lighthouse Service, Steamboat Inspection Service, Coast and Geodetic Survey, etc.

Contact with metallurgical industries is especially provided for through the Non-ferrous and Ferrous Advisory Committees. These committees comprise some fifty prominent industrial metallurgists who keep in touch with the work of the division and who meet at the Bureau annually to receive informal reports of progress and to make suggestions as to the choice of problems and methods of handling them. Many metallurgists and industrialists with metallurgical problems visit the Bureau, and the Bureau metallurgists take all practical opportunities to confer with industrial metallurgists at their plants or at special conferences. It is not unusual for the Metallurgical Division to have personal contact with a hundred other metallurgists in a month, beside the contact by correspondence.

Technical societies or organized technical groups also help to guide the work by suggesting problems demanding study. Close contact is maintained with the American Society for Testing Materials. Other organizations with which contact is maintained are: the American Society for Steel Treating, American Institute of Mining and Metallurgical Engineers, National Research Council, American Foundrymen's Association, American Society of Mechanical Engineers, American Ceramic Society, American Welding Society, etc. Through the Metals Committee of the Federal Specifications Board the Bureau has much to do with specifications for metallic materials.

The metallurgical work is chiefly concerned with fundamental research on the control of properties of metals, and with the development of methods of, and apparatus for, testing. Routine testing is confined to work for other government departments. Tests for individual firms are rarely undertaken, and only when commercial testing laboratories are not yet equipped for some special test, or when data on the material in question are needed in the course of some fundamental investigation. The policy is to coöperate with and not to compete with commercial laboratories. Much attention is paid to supplying information on metallurgical matters to inquirers.

The metallurgical activities may be considered under five heads: optical, thermal, mechanical, chemical, and the experimental foundry.

Optical Metallurgy. The work in optical metallurgy consists of the microscopic examination of metals and alloys for the identification of metallographic constituents, unknown alloys, etc.; X-ray examination for crystal structure; investigation of flaws, defects and other imperfections in metallic materials; study of corrosion and its prevention; development of metallographic apparatus and establishment of metallographic standards; study of coated metals; etching reagents; causes of failure; and preparation of photomicrographs. In the course of each fiscal year approximately two thousand micrographs are taken, the greater part being related to investigations.

Researches are in progress or were recently completed concerning the properties of carbon steel, covering studies of the grain size and hardness, grain size and other mechanical properties, and the tempering of hardened steel; researches concerning non-ferrous corrosion, the studies covering lead, copper, soft metals, tin, aluminum and zinc, and a comparison of test methods, the latter in coöperation with the American Society for Testing Materials; ferrous corrosion, including coated ferrous materials, high-chromium steels, commercial "non-corrodible" steels and a special problem of alco-gas corrosion; corrosion of ferrous and non-ferrous materials, with methods of test, in coöperation with the American Society for Testing Materials; research concerning etching reagents and methods, with reference to copper, copper alloys, nickel and its alloys, aluminum, and the constituents of special steels; study of phosphorus in low carbon steels; electric arc welding, covering the characteristics of arc fused steel, and welded pressure tanks, this work being carried on in coöperation with the American Welding Society and the American Welding Bureau; researches concerning nickel spark plug electrodes; study of the structure of steel at high temperatures; study of defective steels in coöperation with the Army Ordnance Department; research concerning deep etching of iron and steel, covering acid etching and persulphate etching; study of the micro-characteristics of wrought iron; testing of galvanized materials in coöperation with the American Society for Testing Materials; nickbend test for wrought iron, in coöperation with wrought iron manufacturers; research concerning the properties of electrolytic copper; study of the embrittlement of malleable iron in galvanizing, in coöperation with a malleable iron manufacturer; study of the atomic structure of metals by means of X-ray diffraction methods; and an investigation of the carburizing of steel products, covering studies of the initial characteristics of the steel, the structural effects resulting after a standard carburizing treatment, and the result obtained after hardening and carburizing steel; work on machine gun barrels in conjunction with the Ordnance Division of the War Department, covering studies and erosion of machine gun barrels, and electroplating methods of reclamation; special investigation of embrittled duralumin submitted by the Navy Department; investigation of defective invar tapes in conjunction with the Coast and Geodetic Survey; studies of the hardness of metals after different stages of cold-rolling; study of the "scratch" method for determining hardness; an investigation of the properties and structure of ferrite as explained by a possible "hydrogen point"; a study of the austenite to martensite transformation in 28 per cent nickel steel by X-ray crystal analysis, hardness microstructure, etc.; an investigation of the possibility of substituting mechanical puddling of wrought iron for hand puddling.

Thermal Metallurgy. The activities in thermal metallurgy consist of the determination by thermal analysis of critical temperature points and ranges in metals and alloys, and heat treatment of these materials, and the high temperature properties of metals. The thermal analysis covers the location of critical points, survey of heat treatment, and new alloys. The heat treatment consists of annealing and normalizing, hardening and tempering, cementation, and investigation of new alloys, and of quenching media. Several thousand tests have been made in this field in the past two years. Much of this work is being done in coöperation with the American Society of Mechanical Engineers and the American Society for Testing Materials.

Tests and researches are in progress or were recently completed concerning the mechanical properties of metals at elevated temperatures, covering tests of the high-temperature tensile properties of steel and of nickel-copper alloys, and forging and compression tests; heat treatment and lathe tests of high-speed steels, made in coöperation with the Metallurgical and Testing Division of the United States Naval Gun Factory; investigation of dimensional changes in hardening steels; study of the technical quenching media in the hardening of steels; study of methods for rapid annealing or spheroidization of high-carbon steels; research concerning the occurrence of nitrogen in iron; a study, by means of thermoelectric measurements, of the critical ranges of pure iron carbon alloys; investigation of the effects of varying heat treatment upon steels used for permanent magnets; and studies concerning the artificial seasoning of cast iron, the effect of heat treatment on certain non-ferrous light alloys and on corrosion resistance of various steels, and the carburization of steels; investigation of the quality of steel for gages; special applications of "air-hardening" steels in coöperation with the Army; investigation of the density of steel; thermal analyses of nitrified steel; flow of steels at high temperatures; study of high speed steel and machine-ability; quenching media and the mass effect; special investigations of gage steel in conjunction with the gage steel committee including wear, glycerine-water quenching media, cracking of steel on quenching; air-hardening rivets.

Mechanical Metallurgy. This group of activities covers the determination of the physical properties of metals and alloys, the correlation of these properties with structure and constitution, and the effect of temperature, mechanical work, etc., upon them. The activities include: The working of metals, such as forging, rolling, drawing, welding, and soldering; the study of railroad materials, the causes of failure, materials and specifications, rails, wheels and axles, etc.; study of miscellaneous properties; such as the properties of bearing metals, fusible plugs, and the preparation of specifications and nomenclature; the study of manufacturing appliances and processes.

Tests have been made in the past fiscal year of tin boiler plugs and solders, and researches have recently been completed concerning the mechanical properties in compression of white metal bearing alloys at normal and elevated temperatures, in coöperation with the American Society for Testing Materials. An investigation to determine the influence of sulphur, phosphorus, manganese, silicon, and total and combined carbon respectively, on the properties of cast iron of the car-wheel type, also a study of thermal stresses in steel car wheels, both in coöperation with the car-wheel manufacturers, have been carried out. Other work has included: A study of the resistance of steels to wear; an investigation of the deoxidation effect of titanium and silicon on the properties of rail steel; a study of the forging and rolling characteristics of invar; a study of the properties of single crystals of metals; a study of the effect and conditions of hot rolling on properties of steel; a study of the comparative rolling properties of electrolytic iron and open hearth steel; a study of the effect of progressive severe cold-drawing on steels; " red-shortness " in iron; a study of zinc coated materials in coöperation with the Federal Specifications Board; corrosion and exposure tests of screen wire cloth in coöperation with the American Society for Testing Materials; a study of the properties of pure zinc, in coöperation with producers; a study of soldered joints, in coöperation with the Army Air Service; and an investigation of the use of lead filings instead of pipe joint paste.

Chemical Metallurgy. The activities grouped under this head comprise the preparation of metals and alloys from their ores, the development of analytical methods for iron and steel; the preparation of pure metals; and tests of steel and non-ferrous alloys.

Work recently completed or in progress includes: Researches on the determination of gases in metals, separate studies having been made in coöperation with various manufacturers on the method for oxygen and hydrogen, method for total nitrogen and steel, nitrogen as nitrides in steel, oxygen in steel, oxygen in cast iron, and non-ferrous metals; study of the effects of sulphur on the properties of pure iron alloys; preparation and working of pure platinum metals; preparation of platinum-platinum rhodium thermo-couples; preparation of a new alloy suitable for the manufacture of balls to be used in testing very hard steel; and the preparation of special alloys and of ingots, bars, and wire of vacuum-fused pure metals; study of metallurgical auxiliary materials such as refractories, slags, ferro-alloys and deoxidizers, metal-melting furnaces; a special study of induction furnaces in coöperation with the United States Public Health service to prevent mercury poisoning; study of the effect of gases in metals in reference to the relation of oxygen and sulphur in steel, and the quality of pig iron; study of gases in malleable iron; study of sheet steel for welding; development of tarnish-resisting silver alloys; study of hydrogen in steel in coöperation with a member of the Swedish Engineering Academy; and a study of refractories for use in melting platinum and steel.

A study of the effects of small impurities, such as sulphur and phosphorus in steel, is being carried on by a joint committee of representatives of steel manufacturers, railroads and government departments, of which the Director of the Bureau of Standards is Chairman. In this work the steel manufacturers make the steel, and the Bureau of Standards and the War and Navy departments make the tests in their laboratories.

Experimental Foundry Work. Experimental foundry work consists of the making of experimental and practical castings of metals, including special alloys for research and specialized purposes and practical foundry research. The foundry serves the bureau and the research laboratories of other departments and Washington institutions in preparing a great variety of kinds and types of metal and alloy castings.

The Bureau has met with marked success in its experiments on coating materials of all sorts with metallic coatings by spraying. This work has been done for the army and navy and being of a confidential nature no publications have been issued on it.

Several thousand castings of various metals are made per year. Researches in foundry work were recently completed or are in progress concerning electric-furnace practice; lead-zinc bronzes and brasses, molding sands, and the study of nickel alloys for hardware.

To determine the question of sand standards for molding sands, the Bureau is making tests for fineness by the sieve test, the determining cohesiveness or bond strength by the overhanging bar method, thermal conductivity, bond deterioration and measuring the permeability by the rate of flow of a standard volume of air through the sand under standard conditions. Part of this work has been done in coöperation with the American Foundrymen's Association.

Work in Ceramics. The work in ceramics covers tests and research concerning standards of quality, methods of test, and specifications for ceramic materials and products; the study of problems relating to the preparation and utilization of ceramic materials and to the manufacture of ceramic products; the elimination of waste by supplying definite guides to purchasers, governmental and private, and by obtaining and disseminating to manufacturers, scientific information of assistance in the improvement of products and in increasing the efficiency of methods. The products embraced in this work include building materials, such as brick, hollow tile, wall tile, and architectural terra cotta; drainage materials, such as sewer pipe and raintile; paving materials, such as paving brick and floor tiles; refractory materials required for the lining of metallurgical and other furnaces; pottery and porcelains, including dishes, sanitary ware, electrical porcelain and chemical porcelain; and products made by the enameling of sheet iron or sheet steel, cast iron, and other metals.

A special appropriation for "Investigation of clay products" is made annually.

The activities in this field may be considered under three groups, namely, pottery and fine ceramics; heavy clay products and refractories; clay used in paper and textile industries; and enameled metals.

Pottery and Fine Ceramics. The activities grouped under this head consist of tests and researches concerning earthen ware and porcelain tableware, architectural terra cotta, tile, art pottery, chemical and high temperature porcelain and stone ware. They include the study of raw materials, the manufacturing processes, and the burning conditions, and their effect upon the finished product; the development of chemical, physical, and petrographic tests; the establishment of standards of quality and service; the improvement of the quality of products; the replacement of imported materials by domestic products; the development of new uses for clay and clay products; the manufacture of certain porcelains for government use; and studies in kiln efficiency.

In the past two years, thousands of tests were made of raw materials, china, mat glazes, one-fire porcelains, casting slips, tank linings, and terra cotta.

Researches have recently been completed or are still in progress concerning: the physical properties of vitreous china bodies fired at different temperatures, undertaken in coöperation with the research committee of the United States Potters' Association and the American Vitrified China Manufacturers' Association; development of a one-fire porcelain; the bonding power of American and English ball clays in fired bodies; methods of determining the hydrogen-ion concentration of clay suspensions and their effect upon the stability of the suspensions; effect of different rates of drying of clay under different humidity conditions; investigation to determine the comparative effects of the three types of silica in semiporcelain, sanitary porcelain, and vitreous china bodies;

study of compositions suitable for zinc mat glazes maturing at several temperatures; study of the cause and control of the crazing of semivitreous china; investigation of the cause of failure, in glass-melting furnaces, of the high-fire porcelains used in the manufacture of thermocouple protection tubes; study of the physical properties of architectural terra cotta, including physical tests of specimens and burning conditions in terra cotta plants, undertaken in coöperation with the National Terra Cotta Society.

Research was recently begun to obtain physical-chemical constants for the study of clays for specific purposes, and also applicable in processes of their purification, and constants for the regulation of clay bodies for forming the various ceramic wares. Studies are also being made of the effect of the drying treatment of clays on the strength and other physical properties of the ware. Standards are being prepared, in coöperation with the American Ceramic Society for all the raw materials entering into pottery, *i. e.*, felspar, flint, whiting, china and ball clays.

The Bureau has recently developed a combination of body and glaze for the manufacture of porcelain in one fire, this process being devised for the economical and rapid production of whiteware. It has conducted experiments for the development of cements to resist the action of such solutions as acid storage battery electrolytes, photographic fixing solutions, photographic developers, meat pickling solutions, paper stock bleach, and solutions of aluminum sulphate, in order to introduce the use of tile as a tank lining in certain industries, this work being carried on in coöperation with the Association of Tile Manufacturers.

At the suggestion of the Hollow Building Tile Association the Bureau has undertaken a study of the efficiency of hollow tile and brick extrusion machines.

Impact tests on table ware have been made to establish the relation between thickness of table ware, and resistance to impact. The tests covered vitrified porcelain and semiporcelain hotel ware. Besides these laboratory tests, service tests have been carried on at several hotels in coöperation with the American Hotel Association. As a result of these tests standards for this material have been adopted by the Federal Specifications Board. They comprise largely the mechanical properties of the ware and the size to be purchased. The qualities of the glaze, and especially the question whether the glaze of foreign ware is superior to the domestic, are still to be settled.

A comparison has recently been made of china of American manufacture and china produced abroad, and of American clays and foreign clays for ceramic products. It has been demonstrated that with a proper blending of American clays, as good results can be obtained as with foreign clays. The Bureau is now dealing with the question of better bodies and how these should be handled in the process of manufacture.

Heavy Clay Products and Refractories. This group of activities consists of tests and researches concerning: Structural clay products, such as brick, magnesite brick, chrome brick and other special refractories; glass-tank blocks and glass pots; and the development of standards of tests, quality and use.

In coöperation with several heavy clay products associations, the Bureau has completed an investigation of the behavior of different types of clays and shale in the process of water smoking and dehydration. The results of the investigation show means and methods by which kiln time and fuel can be conserved in the burning of heavy clay products in intermittent kilns. The Bureau is studying the working of clays in different clay machines and the quality of the products, including a study of the available clays, which study is intended to lead to the development of specifications for clays for all purposes.

An investigation of the resistance of various types of glass pots to the corrosive action of glass was recently completed. It consisted of a study on a commercial scale, but with laboratory precision, of the effect of varying body compositions and methods of burning on the resistance to the corrosive action of the glass. It is now studying the corrosive action of glass on glass tank blocks in a small glass tank in which are melted about 500 pounds of glass daily.

In coöperation with the Refractories Manufacturers' Association the Bureau prepared specifications to be used by the various government departments in the purchase of refractories. It deals specially with refractory brick for the lining of boiler settings. A progress report on the correlation of laboratory and service tests of refractories with special reference to refractories for stoker-fired boiler settings, has recently been published. A short investigation was recently carried on with refractories for rotary cement kilns. This work indicated the requirements of specifications for this type of refractory.

The Bureau is also making a comprehensive study of problems relating to saggers, in coöperation with the United States Potters' Association.

A study of the change in the constitution and structure of refractories used in different parts of glass-melting furnaces has been undertaken in order to determine the cause of failure in glass-house refractories.

Clays Used in Paper and Textile Industries. Demonstrations have been made by the Bureau that the American clays available for the paper industry can be used very largely to replace foreign clays, and the Bureau is planning work looking toward the replacement of the imported clay in the textile as well as the paper industry.

Enameled Metals. The activities under this head were begun during the fiscal year ending 1919, the researches being originally undertaken to find means of overcoming the difficulties encountered in the manufacture of enameled cast iron and steel products. Experiments are being made in the enameling of ferrous and non-ferrous metals; the effect of raw materials; compositions, melting, and metal surface on the finished product; and the development of standards of test methods and of quality.

Among the researches and tests in progress or recently completed are: An investigation on the enameling of sheet-steel for kitchen ware; on cast iron for enameling purposes in coöperation with the Enamel Division of the American Ceramic Society; on substitutes for tin oxide in white enamels for sheet steel; and on causes and remedy for specking of ground coat enamel. A great deal of work has been done in the development of enameling by the wet process.

Work in Glass. This activity had its origin before the World War but the rapid development was induced by the scarcity of optical glass during the period. Before the war the optical industry in the United States was almost negligible, but the Bureau took steps to meet the emergency created by this scarcity, and as a result, has developed a quality of glass that is at least as good, and in some respects better, than foreign made glass. About 12 per cent of the glass used during the war for high-grade optical instruments was made at the Bureau. It is not the intention of the Bureau to compete with private manufacturers in this country, but, on the contrary, to aid this key industry by maintaining a nucleus of skilled experts in the field of optical glass production, which is of very great military importance. By this service the Bureau stimulates the domestic optical instrument industry, which has rapidly grown since the war.

A special appropriation by Congress for "Investigation of optical glass" is made annually.

The Bureau studies the relation between the chemical composition of various kinds of glasses and their physical and optical properties, including investigations of plant and laboratory methods of melting glass, molding, annealing, and testing glass products, such as optical glass, sheet glass, and glass tableware; testing the resistance of glass to weathering and the solvent action of water, and the strength of glass for glazing; and studying the manufacture, physical properties, and service conditions of glass containers. It has done much pioneer work in this country in the production of optical glass and has accumulated, through its investigations, a vast amount of information regarding glass production and the properties of glass which has enabled manufacturers to improve their products. It has also been enabled to recommend specifications concerning glass products.

During the year 1924, forty-five pots covering four different types of optical glass were melted with the object of studying and improving methods for making this material. About 2000 pounds of this glass is used by the government. About 7000 pieces of optical glass were molded and made into blanks. The Bureau is studying methods of making large discs, in which it is looking forward to early success.

The Bureau has made the glass for, and has ground and finished, a 12-inch lense, which is the largest lens produced in America from American-made glass.

Researches were recently made or are now in progress concerning the composition and optical properties of glass; studies of the physical properties of optical glass, especially viscosity at high temperatures, and on the scumming of glass bottles, in coöperation with the Glass Container Association; and research on "stones" in glass. Tentative specifications for sheet glass have been prepared in coöperation with manufacturers and consumers of sheet glass, in which the nomenclature, definitions, classification, faults, size, tolerances, etc., are discussed.

The Bureau has recently held conferences with milk bottle manufacturers, cup makers, milk dealers, and dairy inspectors, at which plans were discussed to standardize the shapes, capacity, marking, and labeling of milk bottles, and to consider the possibilities of adjusting state and municipal laws and regulations to conform to such standards. Methods of marking were adopted by the conference and the Bureau was delegated to present this phase of the work to the state and municipal authorities concerned.

As in the case of chinaware and other products, the Bureau, in coöperation with other branches of the federal government, has prepared specifications for glass for use in all government departments.

The Bureau has designed, assembled, and calibrated apparatus for measuring the vicosity of glasses at different temperatures.

Standardization of Equipment. Under this head are included activities in the nature of coöperation with government departments, municipalities, engineers, and manufacturers, in the establishment of standards, methods of testing, and inspection of instruments, equipment, tools, and electrical and mechanical devices, including efforts looking to the reduction of the number of sizes and types of standard commodities.

These activities are mainly carried on under an annual special appropriation for "Standardization of equipment."

Simplified Practice. Since October, 1921, the Bureau, through the creation of a Division of Simplified Practice, has been coöperating with American business groups in developing a nation-wide program for the elimination of waste in commerce and industry, by effecting a reduction in the number of sizes and types of standard products, the abandonment of useless varieties, and the concentration of the attention of manufacturers upon articles of the greatest interchangeability.

In this work the Bureau operates by calling together, in a group, as occasion permits, representatives of a particular industry for the consideration of products to be simplified and the recommendation for adoption of the conclusions reached by the conference. It sets up a centralized agency to bring producers, distributors, and users of specific articles together, and supports the recommendations of those interested whenever they agree upon a certain program of simplification which will benefit the industries and the public. On December 15, 1924, 232 industrial groups were coöperating with the Bureau in this simplification work.

By this means, much confusion, uncertainty, and waste in industry have been eliminated. Thus as a result of about three years' efforts in this field, agreements have been made to reduce the number of sizes and styles of vitrified paving brick from sixty-six to five; bedsteads, springs, and mattresses from seventy-eight to four; metal lath, from 125 to twenty-four; asphalt (penetrations), from eighty-eight to nine; hotel chinaware, from 700 to 160; files and rasps, from 1351 to 496; rough-face brick, from thirty-nine to one; smooth-face brick, from thirty-six to one; common brick, from forty-four to one; range boilers, from 130 to thirteen; woven-wire fencing, from 552 to sixty-nine; woven-wire fence packages, from 2072 to 138; milk bottles, from forty-nine to nine; milk bottle caps, from twenty-nine to one; bed blankets, from seventy-eight to twelve; hollow building tile, from thirty-six to nineteen; roofing slate, from ninety-eight to forty-eight; blackboard slate, from 251 to twenty-five; forged tools, from 665 to 351; asbestos paper, from fourteen to eight; asbestos millboard, from ten to five; steel barrels and drums, from sixty-six to twenty-four; brass lavatory and sink traps, from 1014 to seventy-two; hot water storage tanks, from 120 to fourteen. In the case of structural slate, there was a reduction of 87 per cent in slate for plumbing purposes, and 83 per cent in slate for sanitary purposes. In the case of paper, the reduction was indeterminable. There were also effected, standard nomenclature, grades, and sizes for soft-wood lumber.

Simplified practice recommendation have been approved at general conferences of manufacturers, distributors, and users, and are now in process of acceptance in the case of the following items: Plow bolts, builders' hardware, cafeteria and lunch-room chinaware, concrete building units, cotton duck, eaves trough and conductor pipe, hospital beds, loaded shells, sheet steel, steel lockers, steel reenforcing bars, tern plate, hot water storage tanks and warehouse forms; involving altogether the reduction of many thousands of varieties of the items mentioned.

The services of the Bureau are being utilized in efforts for simplification and standardization of products by the following industrial groups, the number of projects being given in each case:

By producers and manufacturers of lumber, two; farm equipment, four; hardware, four; containers of wood, glass paper, and metal, thirteen; automobile parts, five; building equipment, eleven; building material, sixteen; clay products, four; machinery, thirteen; marine field, seventy-nine; metal ware, seven; steel items, five; textiles, five.

The Bureau recently completed the preparation of two reports on utilization of waste in the lumber industry, one covering a survey made in the Pacific Northwest and the other in the Southern States.

In addition to the above, it has rendered more or less service in this field of endeavor to the following industries: Production of men's, women's and children's shoes; railway equipment; hospital supplies; mining supplies; oil-well supplies; plumbing supplies; concrete mixers; registers for warm-air furnaces; household refrigerators; crucible refractories; concrete refractories; cast-iron pipe; copper and brass products; mechanical stokers; machine tools; twist drills; watches and clocks; fish containers; dining-car supplies; safes; linoleum; chemicals; rubber heels; and machinery.

At the suggestion of the American Marine Association of New York City and in coöperation with the Bureau of Standards, an American marine standards committee has been organized whose function it is "to consider, encourage, promote, adopt, and promulgate, in coöperation with all interests concerned, any measure, such as standards, rules, or recommendations to bring about simplified practice in the fields of engineering, commerce and industry, as affects shipbuilding."[11] A general conference of this committee met on May 5, 1924, to consider existing specifications for condenser tubes and ferrule stock and to adopt recommendations for a common standard for marine use. The committee also coöperates with similar foreign bodies in this effort at simplification.

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[11] A publication was recently issued by the Bureau on the "Organization of the American Marine Standards Committee and its Constitution and Rules," which describes the field, objects, organization, and mode of procedure of this committee.

The leaders of industry are looking more and more to the Bureau of Standards to act as a consulting agency in matters relating to the elimination of unnecessary varieties of commodities. Up to July 31, 1925, 188 conferences had been held in Washington concerning simplification of practice, sixty articles had been published in news and trade papers, and many formal addresses had been given throughout the country on the subject, and the Bureau had been represented at fifty meetings of business committees and conventions where simplified practice was advocated.[12]

Preparation of a Directory of Specifications. The Bureau of Standards is engaged upon the formulation of a directory of specifications, intended as a handbook for the American buyer. It is a list of specified articles intended to enable a person who wants to buy steel, concrete, engineering materials, or other commodities, to get either a reference to an existing specification or the actual specification itself. Wherever satisfactory available lists and specifications exist they are not reproduced but only referred to in the book. The directory will give first-hand information concerning all available specifications, and will thus enable the government to systematize materially its purchasing.

In the preparation of this directory, the Bureau has the advice of a committee composed of heads of national business and technical organizations and is assisted by the Commodity Division of the Bureau of Foreign and Domestic Commerce and other branches of the government, by the State Purchasing Agents' Association, and other organizations.

Coöperation with the Federal Specifications Board. The Federal Specifications Board was organized, by direction of the President in October, 1921, as a branch of the Bureau of the Budget, for the purpose of preparing specifications for commodities to be purchased by the government in order to unify purchase requirements and effect economies.[13] It is made up of representatives from each department and independent establishment purchasing materials or services in accordance with specifications prepared in such establishment. This board compiles and adopts standard specifications for materials and services, and brings specifications into harmony with the best commercial practice wherever the conditions permit. It standardizes nomenclature and dimensions in order to insure ready interchangeability of supplies and interworking parts made by different manufacturers, and limits the number of types, sizes, and grades of manufactured products used by the government. The detail work of the board is performed by about seventy committees working under its direction.

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[12] A pamphlet on "Simplified practice: what it is and what it offers," published by the Bureau, Nov. 26, 1924, describes this activity in greater detail.

[13] See Circular 42, Treasury Department, Bureau of the Budget, October 10, 1921.

The Director of the Bureau of Standards is ex-officio chairman of the board, and the Bureau's staff is represented on nearly all of the sixty-five technical committees of the board, holding chairmanships of twenty-four of them. The Bureau's work in connection with the Federal Specifications Board, aside from representation on the board and on its committees, is to carry out the actual experimental work involved in a great many of the government specifications. While formulating specifications, members of the board are constantly being referred back to the Bureau's laboratory for facts. During 1924, the Bureau assisted the Federal Specifications Board in the preparation of 162 specifications of commodities for government use. The overhead work of the Federal Specifications Board is paid for out of the Bureau's appropriation for "Standardization of equipment." The Bureau expends about $112,000 annually for work in connection with the development of these specifications.

Following is a summary of the activities of the Bureau that have recently come under the head of Standardization of Equipment:[14]

Specifications for electrical measuring instruments prepared; specifications for various electrical supplies collected and revised for Federal specifications board; specifications for electric lamps revised; general movement for better automobile headlights inaugurated in coöperation with state officials and others; standards of the American Institute of Electrical Engineers translated into Spanish; new specifications for dry cells issued; data collected for specifications for sulphuric acid; recommended standard items of builders' hardware for hollow metal doors, and formulated an arrangement of holes in templet butts, together with rules for butt sizes on hollow metal doors; standardization of method of test for elevator safety devices; standard design data for telescope and microscope objectives, collected and issued; standard design data for telescope and microscope eye-pieces collected; performance specification for anastigmatic lenses prepared and issued; forty-five conferences were held in the program for eliminating waste in commerce and industry through reduction in the number of sizes and types; two industries, paving brick, and bedsteads, springs and mattresses, have acted; five simplified practice projects have been formulated, and are now being approved; these include metal lath, flags, hollow building tile, concrete products, and glass, paper, metal, and wood containers; completed an investigation of plumbing in small dwelling house construction; completed accelerated service test on the relative wearing value of ballbearing and steel-bushed bronze butts; investigated the serviceability of a 3-inch soil stack for large plumbing systems.

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[14] Hearings on Department of Commerce appropriation bill, 1925, p. 305.

Building and Housing Service. One of the major functions of the Bureau of Standards since July 1, 1921, as defined in the special annual appropriation for "Testing structural materials," is "to collect and disseminate such scientific, practical, and statistical information as may be procured, showing or tending to show approved methods in building, planning, and construction, standardization, and adaptability of structural units, including building materials and codes, economy in the manufacture and utilization of building materials and supplies, and such other matters as may tend to encourage, improve, and cheapen construction and housing." The expenditures for this service are also in part met out of the special annual appropriation for "Standardization of Equipment."

In carrying out this work the Bureau aims to increase and improve housing facilities in the United States by rendering such service as will aid in eliminating waste in building by securing standardization of building materials and plans, and better building construction. In this endeavor it has enlisted the coöperation of other branches of the government, and has established contacts with state and municipal authorities and with civic, engineering, trade, and other organizations throughout the country. It presents its conclusions through its own and other government publications, the trade press, and direct communication with private organizations and individuals.

These building and housing improvement activities may be considered under five groups, namely: Collection and distribution of current statistical information concerning the building industry; economic and statistical studies; studies to effect elimination of waste in building; service to home owners; and technical service to municipalities.

Compilation of Current Statistics. The Bureau collects and publishes current statistics of retail prices of building materials, production, and stocks, and of building activities, this service being intended to enable engineers, architects, and builders to make more accurate estimates of building costs, and to keep the general public informed of the status of the construction industry.

A monthly table of building material prices for twenty-four items as paid by contractors in about fifty cities is compiled and published in building trade papers. The data are also used by the Bureau of the Census in compiling index numbers of the price materials for small frame and brick houses.

The Bureau coöperates with the editor of the Survey of Current Business, a monthly publication of the Department of Commerce, in obtaining, compiling, and publishing figures on building activities, building costs, and production, consumption, and stocks on hand of the principal building materials. It also serves as a clearing house for inquiries concerning statistics of building and building materials collected by other government departments.

Economic Studies. Studies are made from time to time on subjects relating to tenancy and home ownership, home building, etc. An investigation has been made, in coöperation with the construction committee of the President's Conference on Unemployment, of seasonal operations in the construction industries. This covered operations in the lumber, brick, cement, and other industries, and the effect of their seasonal character upon the industry, the worker, commerce and public welfare, as well as a consideration of proposed remedies. The result has disclosed the possibility of extending many construction operations into the winter season, and an educational campaign is being carried on for such an extension.

In response to a request from the President for advice "as to the policy which ought to be pursued in view of the present economic situation in the building industries, with a view to determining how much to speed up on the construction program," a study was recently made of the construction activity and demands for construction in relation to the capacity of the construction industries as measured by the supply of building trades labor, building materials, and transportation facilities.

At the request of a number of national organizations, the Bureau is at work upon the preparation of a standard state mechanics' lien bill, on which it has the voluntary coöperation of organizations representing contractors, material dealers, labor, financing agencies, architects, and other groups.

Waste Elimination. The Bureau, through its divisions of Building and Housing, and Simplified Practice, is coöperating with the various branches of the construction industry in efforts to elminate waste and provide better homes at less cost. It is endeavoring to bring to the attention of builders and manufacturers of building materials the possibility of saving through greater simplification of building, and the elimination of unnecessary dimensional varieties in construction, with the view of effecting a reduction of cost and increasing the availability of needed materials. The manufacture for stock is also encouraged in order to bring about a reduction of the seasonal fluctuation in the operations of building-material producers.

Assistance and encouragement have been given to efforts to lengthen the building season so that workers in the building trades will have more constant employment, and to a movement to distribute leasing dates throughout the year, thereby eliminating the existing artificially created demand for buildings and apartments at certain seasons. The study of seasonal construction was initiated at the instance of a committee of the President's Conference on unemployment, with the result that constructive remedies based mainly on what has been accomplished in various communities, have been evolved, and the suggestions are being carried out in many towns and cities.

Service to Home Owners. The Bureau endeavors to assist individual home owners by the publication of advice concerning the financing and choosing of sites for and taking care of homes, and by coöperation with movements for better housing. It has assisted in the activities of the "Better Homes Demonstration

Week" in 1922 and 1923, carried on by the "Better Homes in America" agency, the chief aims of which are to teach, by demonstration, good standards of design, construction, decoration, furnishing, equipment, and operation of homes; in brief to encourage the maintenance of well-balanced homes, in which the value of the house, the lot, and the furnishing and equipment are properly proportioned; also to show how homes can be improved and housework reduced at an expense within the reach of small incomes. Through this agency, information collected by the different government departments reaches hundreds of communities in every part of the country. Several bulletins have been issued for the guidance of home buyers and home builders.

In this "Better Homes in America" agency are associated eight federal government officers, and representatives of the principal national organizations of women's clubs, business men, architects, the American Red Cross, and other groups interested in child welfare and public health. It is an incorporated agency supported by voluntary contributions.

In 1923, the Bureau issued a brochure, "How to own your home," three hundred thousand copies of which have been sold.

The Bureau has given its encouragement to the "Architect's Small House Service Bureau," a non-profit-making organization, fostered by public-spirited architects throughout the country, the purpose of which is to assist persons in obtaining house plans which employ standard sizes of materials and provide for economical and livable homes, thus affording opportunity to secure architectural service for small homes at low cost, and reducing construction costs by good planning and by eliminating waste space.

Technical Service to Municipalities. In order to aid in making state and city building and plumbing regulations more effective and less burdensome, and securing greater consistency throughout the country, the Bureau has undertaken to bring together professional men representing interested organizations throughout the country for the purpose of conducting centralized research and making recommendations to states and municipalities for standard local building and plumbing codes and zoning regulations. In carrying out this purpose the Bureau has brought about the organization of three committees, the Building Code Committee, the Plumbing Code Committee, and the Zoning Committee, each of which, in coöperation with the Bureau, is engaged in the preparation of a code of regulations.

The building and plumbing code committees consist of members of such leading technical and professional organizations as the National Board of Fire Underwriters, American Society of Mechanical Engineers, National Fire Protection Association, American Institute of Architects, National Research Council, American Concrete Institute, American Institute of Consulting Engineers, American Society for Testing Materials, National Board for Jurisdictional Awards in the Building Industry, American Society of Civil Engineers, Iron and Steel Institute, American Foundrymen's Association, American Public Health Association, American Society of Sanitary Engineering, American Water Works Association, National Association of Master Plumbers, American Federation of Labor, and United Association of Journeymen Plumbers.

On the Zoning Committee are members of the National Association of Real Estate Boards, Chamber of Commerce of the United States of America, National Conference on City Planning, National Municipal League, American City Planning Institute, American Civic Association, American Society of Landscape Architects, and the National Housing Association.

The three committees meet at frequent intervals, usually in Washington, to draft reports, and to give advice regarding the work being carried on in their respective fields by the Bureau. Before a code recommendation is adopted by any of the committees, it is submitted for suggestion and criticism to interested organizations and individuals.

In connection with the work of the Building Code Committee, the Bureau has made special tests of materials and methods of using them, the results of which were used in drawing up the committee's recommendations.

The first report of the Building Code Committee was recently completed. It is entitled "Recommended minimum requirements for small dwelling construction." The report is regarded as the most thorough investigation that has ever been made of the engineering and practical side of house building, its purpose being to avoid needless waste of materials required in many building regulations while providing for proper safety, comfort, and durability. It sets forth proposed requirements for the construction of one-

and-two-family houses of masonry, poured concrete, and frame types, including veneer and stucco. An appendix contains information on the quality of materials and methods of workmanship which should be used for good results, tables showing safe sizes of floor joists and girders, and other interesting facts. The building code for small dwellings has been adopted by a considerable number of municipalities.

Upon completion of this report, the Building Code Committee took up the consideration of regulations governing live-load assumptions and the construction of masonry walls in buildings of other types. A report on masonry wall requirements and on floor load requirements has recently been printed.

The Plumbing Code Committee, composed of sanitary engineers and plumbing experts designated by the Secretary of Commerce, has been concentrating most of its attention upon problems connected with small-house plumbing and drainage systems, although much of its work also applies to buildings of larger types. Extensive tests are being made to ascertain how safe plumbing systems can be economically installed, so that unnecessarily expensive installation requirements in plumbing and sanitary codes may be eliminated. Efforts are also being made to effect a greater uniformity in types of traps and other fittings so that plumbing fixtures may be standardized and cheapened. A survey of plumbing requirements in a large number of cities disclosed that many unnecessary variations exist which increase the cost of installation. Many of these requirements were based on no real reasons, but were the product of rule-of-thumb methods and local prejudice. It is estimated that the elimination of unnecessarily severe requirements will save millions in building costs. A standard plumbing code of 260 pages was recently published by the Bureau, based on the results of these studies. The adoption of this code by state and local governments, it is estimated, will permit savings of $50 to $200 per house to the owner.

The Zoning Committee, in 1923, formulated a standard state zoning enabling act. The purpose of a zoning law is to permit cities to zone, that is, to divide the city's area into districts each of which is regulated according to its use, such as for residence, business, or manufacturing purposes. The zoning regulations control the use and height of buildings and the area of the lot that may be built upon, the regulations varying in the different classes of districts or zones into which the city is divided. In formulating this standard act, care was taken to insure as far as possible its standing up under court decisions. This standard act was made the basis of bills introduced in many state legislatures, at least thirteen of which have been enacted. During less than two years of existence of the zoning committee the number of zoned municipalities increased from forty-three to 155, and the population affected increased from 11,000,000 to 23,000,000. The Board has prepared and published "A zoning primer," which explains the elements of zoning, and contains a selected bibliography.

Contact with Building Trade and Other Organizations. In order to make its work in the field of building and housing effective, the Bureau works in close coöperation with public officers and with architectural, engineering, and trade associations in obtaining material for technical investigations, and distributing this information. It has important contacts with the American Civic Association, the American Institute of Architects, the American Statistical Association, the Associated General Contractors, the Chamber of Commerce of the United States of America, the National Association of Builders' Exchanges, the National Association of Real Estate Boards, the National Congress of the Building Industry, the National Housing Association, and the United States League of Local Building and Loan Associations.

Rope Investigation. The Bureau has been endeavoring to determine, if possible, a non-destructive test of mine ropes, and the cordage people are interested in tests for cordage. Studies have been made, and are in progress, of the effect of mechanical stress on the magnetic properties of steel wire; of the effect of wear; and of the effects of fatigue and corrosion. The work of designing and constructing apparatus for field tests is under way. The Bureau of Mines is interested from the point of view of mine inspection. Appropriations for this work were made for the fiscal years ending 1924 and 1925, but were not repeated for the year 1926.

Personnel Instruction. Although it is not a function of the Bureau of Standards to give formal courses of instruction to its employees, it has from its beginning encouraged and facilitated coöperation among the members of its scientific staff, and has provided means for the technical education of its employees.

When the Bureau was established in 1901, weekly meetings were begun of the members of the scientific staff, for the discussion of the technical work, and criticism of progress reports and other technical developments.

In 1902 informal weekly journal meetings were begun, the meetings being held sometimes during and sometimes outside the regular office hours. Originally the physical and chemical divisions had joint meetings, but since 1913 they have been meeting separately.

In 1910 a physics seminar was started, the meetings being held outside office hours. Since the war, the physics journal meetings and the physics seminar have been combined, a seminar paper being presented once a month.

In 1908 graduate courses of instruction in physics, mathematics, and chemistry were inaugurated, a work which has since been carried on upon a semi-official basis. Its object is to give the younger members of the staff a better training for their technical duties.

This educational work is under the administration of a committee of six members of the staff, four of whom are appointed by the Director, and two are elected annually by the student body from among their own number. While this committee exercises full control of the school, the student body is consulted in the arrangement of the courses and the selection of the instructors.

Since the organization of this school, from two to eight courses of instruction have been given per year. The classes are in session before and after the regular working hours. The courses have been limited to the general field of physics, mathematics, and chemistry, along lines similar to those offered in the graduate schools of the leading universities. Two three-year cycles are regularly provided, one in physics and one in mathematics, and as many additional courses as can be supported. The tuition fee is $15 per year-hour.

The greater part of the instruction is given by persons not connected with the Bureau's staff, the policy of the school being to give preference to outsiders.

Most of the leading universities have recognized and credited class work done at the school in the awarding of graduate degrees.

Courses for undergraduate members of the Bureau's staff were begun in 1918, and summer courses have also been conducted.

The legal authority under which this educational work is maintained is a resolution passed by Congress April 12, 1892 (27 Stat. L., 395), which opened the government collections for research and educational uses, and an act of March 3, 1901 (31 Stat. L., 1039), which provides that "Facilities for study and research in Government departments . . . shall be afforded to scientific investigators and to duly qualified individuals and students . . . under such rules and regulations as the heads of departments and bureaus may prescribe."

These conferences and classes have greatly strengthened the efficiency of the Bureau of Standards, as they have enabled the personnel to do better work. They have been instrumental in qualifying the Bureau's employees for promotion and for more lucrative employment in private service.

Research Associates Plan of Coöperation. A plan of coöperation adopted by the Bureau, whereby an industry or organization can send a representative to the Bureau to work on some particular problem, is outlined in the following extracts from a recent publication:[15]

> Immediately following the war the growing demands for highly trained technical men to meet the increasing demand for industrial research, threatened the Bureau with a depletion of its staff and thereby a curtailment of its research activities. This situation led to the establishment by the Bureau of a Research Associate Plan, whereby a manufacturer or association of manufacturers might place a graduate physicist, chemist or engineer, at the Bureau for a period of one or more years to carry on investigation in some particular line.
>
> This plan has proved valuable, both in the training of additional research specialists by association with the Bureau staff and in maintaining the research output of the Bureau in lines which are of special industrial importance.
>
> The Bureau of Standards, with an eye to the public welfare, coöperates wherever feasible with the industries in the development

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[15] Circular Letter No. 119, Bureau of Standards, May 1, 1924.

and promotion of higher standards and minimum production waste in the commodities of commerce. In effect, therefore, the research associate plan is a plan for coöperative investigation to such ends. The work undertaken under this plan is such that it would be done by the Bureau alone if its funds were sufficient. The coöperative method may be, however, somewhat more certain of practical results and these results thereby likely of quicker adoption. Coöperative work is not encouraged except in fields where the Bureau has rather complete equipment and highly specialized personnel to give advice and assistance.

After deciding that the results to be obtained will be for the general welfare of the industry and the public, and an agreement has been reached with the industry, a candidate is sought for the position of research associate. In some cases the Bureau takes the initiative in this search, in others the employer. In either case both parties agree upon the man and his qualifications—usually a graduate in technical lines with the equivalent of one or more advanced collegiate degrees.

Upon appointment, the research associate is assigned to one of the divisions, his status becoming that of a Bureau of Standards employee, subject to the same rules and regulations and with the rights and privileges, including the privileges of advice and consultation. This includes the working periods, accrued and sick leave, previous notice of travel, etc. The Bureau does not, however, handle his pay.

Each research undertaken by the associate is authorized in the customary way by the Director, at the request of the section and division to which the research associate is assigned, previous agreement with the supporting industry having been arrived at.

* * * *

The results of the investigations are immediately available to the supporting industry and reported to the general industry through the official channels of the Bureau. The Bureau reserves the right to publication, which if desired may be made a joint contribution of the research associate and the Bureau representative immediately responsible. Informal consultation with representatives of the industry on the problems under investigation is always welcomed.

It is expected that the work of the research associate shall be for the general interest of both the industry and the public, and therefore in general will not be patented.

* * * *

Measure of Activities. The following table which shows in detail the number of tests made for the public and for the government service during the fiscal year, 1924, gives some idea of the measure of the activities of the Bureau of Standards.

TESTS MADE IN THE FISCAL YEAR, 1924.

Nature of test	Tests for the public		Tests for the government	Bureau tests in connection with research and standardization	Total tests
	Number	Receipts			
Length:					
Tapes	103	$245.75	90	15	208
Sieves and sieve cloth	294	616.25	100	91	485
Gauges and gauge materials	1,216	473.25	297	3,578	5,091
Miscellaneous	958	1,259.30	138	87	1,183
Mass:					
Weights	3,811	1,717.00	841	1,046	5,698
Balances	1	1.00	8	12	21
Scales	1	4.00	1,188	122	1,311
Time (clocks, watches, etc.)	457	740.00	15	61	533
Capacity:					
Volumetric glassware	5,221	2,966.05	2,018	576	7,815
Miscellaneous	58	202.45	98	238	394
Density:					
Hydrometers and thermohydrometers.	770	1,345.95	313	......	1,083
Miscellaneous	59	88.75	......	211	270
Electrical tests	670	4,458.98	410	1,450	2,530
Photometry	207	573.00	3,152	60	[a]3,419
Temperature:					
Clinical thermometers	14,026	1,174.18	3,631	......	[b]17,657
Other thermometers	1,939	4,534.10	762	69	[c]2,770
Miscellaneous	341	1,953.24	102	5,154	5,597
Optical:					
Sugar polarimetry	26	90.50	1,888	65	1,979
Miscellaneous sugar tests	......	......	......	819	819
Miscellaneous	239	1,846.80	74	3,032	3,345
Radioactivity:					
Radium	1,110	9,614.00	1	......	1,111
Miscellaneous	70	355.60	3	......	73
Chemical analyses:					
Cement	......	......	2,361	......	2,361
Other materials	7	207.50	5,070	1,518	6,595
Standard samples	4,446	9,187.75	477	......	4,923
Mechanical instruments and appliances	61	361.50	575	6	642
Aeronautical instrument tests	5	17.50	52	73	130
Physical tests of materials:					
Cement	5	11.00	9,070	......	9,075
Concrete, aggregates and miscellaneous materials.	......	......	1,143	1,823	2,966
Other structural materials	90	238.20	2,946	2,940	5,976
Leather, rubber, etc.	4	3.00	1,318	65	1,387
Textiles	79	373.50	4,595	......	4,674
Paper	339	1,043.00	1,477	164	1,980
Lime, gypsum, etc.	6	30.00	10	154	170
Metallurgical tests:					
Castings	......	......	913	1,480	2,393
Fusible plugs	......	......	571	......	571
Miscellaneous	19	358.00	117	984	1,120
Ceramic tests	6	30.00	166	27,263	27,435
Miscellaneous tests	4	35.00	58	......	62
Total	36,648	$46,156.10	46,048	53,156	135,852

[a] In addition, the bureau inspected 1,619,798 incandescent lamps at various factories for other departments of the government.

[b] In addition, 6717 clinical thermometers were submitted, all of which were rejected.

[c] In addition, 210 other thermometers were submitted, all of which were rejected.

Economies Effected through Activities. Following are a few examples of the many economies effected by, or which resulted from, the work of the Bureau of Standards.

By the adoption of a plumbing code, by state and local governments, which was prepared by the Bureau and is based on a thorough study of actual installations and many laboratory tests, great savings are being effected by builders and house owners. The alteration of one requirement alone that formerly was in general use, is estimated to effect a saving of about $1,000,000 per year in building costs.

The Bureau has developed a laboratory service test of elevator interlocks, which has been adopted by the city of Baltimore, and which, when generally adopted, is expected to reduce very materially the number of elevator accidents and will enable insurance companies to reduce insurance rates on elevators using interlocks that have passed this test.

By bringing about a reduction in the number of unnecessary sizes and useless varieties of articles in common use, great economies have been effected in industry, as shown on page 173.

In coöperation with the American Gas Association the Bureau has made a thorough study of the adjustment of gas burners, and of the relation of burner design to the nature of the gas supply, resulting in the diminution of danger from carbon monoxide.

Investigations made by the Bureau in coöperation with the American Dental Association, of inlays and other materials used in dentistry, are expected to bring about superior dental work and to effect savings of millions of dollars annually in dental costs.

The Bureau has developed methods of preparation of levulose, which will make it possible to produce it at a price low enough to place it on the market. Before this development levulose could not be produced for less than $30 per pound. It is expected to reduce the cost of production of levulose by the methods developed, below that of beet sugar.

Radiometric measurements on paints and other materials, made by the Bureau, have shown that the use of paints containing aluminum or bronze pigments are poor radiators, and when used on household radiators, the latter requires about twenty per cent more surface for the same heat effect as when other paints are used. On the other hand, automobile and ice wagon tops and tents painted with aluminum or bronze paint let through much less heat from the sun than when unpainted or painted with other materials.

Among other instances where material economies were effected through the services of the Bureau may be mentioned: the standardization of hardware finishes by a committee of hardware manufacturers under the leadership of the Bureau and the adoption of twenty-five standard finishes by a conference of manufacturers; the adoption, by the lumber industry, of a logging and sawmill safety code, which will result in the saving of life and property; the development of an improved method of establishing radio frequency standards, etc.

The Bureau has assisted the Federal Specifications Board in the preparation of 162 specifications of commodities for government use during 1924. The Bureau holds chairmanship of twenty-four committees and is represented on nearly all of the sixty-five technical committees of that Board. These specifications are of great value to the government in unifying purchase requirements and effecting economies.

CHAPTER III

ORGANIZATION

The Bureau of Standards is organized into two main groups, the administrative, operation, and construction branches on the one hand, and the scientific and technical on the other. There are fourteen divisions and sixty-six sections. Four divisions have no subordinate sections. The others have from four to ten sections each. On May 15, 1925, there were 736 persons in the employ of the Bureau. A vast amount of work is accomplished through coöperation with scientific, technical, industrial, and governmental organizations, especially through advisory committees.

The executive head of the Bureau is the Director, who is appointed by the President "by and with the advice and consent of the Senate." All other officers and employees are appointed by the Secretary of Commerce, mostly from the eligible lists of the Civil Service Commission. A division chief is at the head of each division.

The divisions are: the office; operation; construction; weights and measures; electricity; heat and power; optics; chemistry; mechanics and sound; structural, engineering, and miscellaneous materials; metallurgy; ceramics; simplified practice; and building and housing.

Office of the Director. The Director has general supervision over both the scientific and the administrative work of the Bureau. An assistant director, whose duties are administrative, a secretary, an assistant to the director who is chief of the Office Division, and a stenographer constitute the personnel of his office. The Director is ex-officio chairman of the National Screw Thread Commission and of the Federal Specifications Board. In his specifications work he has the assistance of three technical and eight office employees.

The Office. This is the name given by the Bureau to its administrative division. Its work comprises the supervision of the units of the administrative branch; the selection, recommendation, and assignment of office personnel; the planning and supervision of routine clerical work; the supervision of editorial work; and maintenance of the technical library.

The Office handles the accounts of receipts and expenditures for equipment, supplies, personnel, travel, and general expenses; the personnel work and records of the staff; the accountability records and operations relating to apparatus, equipment, tools, and furniture; the procurement, storing and distribution of scientific and other supplies; the handling and filing of communications; the maintenance of a technical library and of a technical catalogue library; the examination of manuscripts submitted for publication and the editorial preparation for publication of those accepted and approved; and the issuance and official distribution of the scientific, technologic and other publications, and of the monthly "Technical News Bulletin," and their official distribution through regular channels. The chief of the Office Division, who is also assistant to the Director, has the help of two office employees. The office comprises seven sections.

Finance Section. The Finance Section records the receipt of appropriations and transfer of funds from other departments; accounts for such funds under their respective allotments by means of order and voucher records; prepares all pay rolls, and keeps current records incident thereto; audits and approves all vouchers for payment; checks disbursing office voucher abstracts; prepares semi-monthly financial statements and other financial reports called for by the Bureau of the Budget; has the custody of all cash receipts, and compiles the annual estimates and fiscal statistics connected therewith. The Bureau receives no money return except in appropriations and in funds transferred from other departments. All fees received for tests are turned into the Treasury. The personnel of this Section consists of a section chief and five office employees.

Personnel Section. The Personnel Section keeps the personnel records, including a visible index and directory of all employees; records of entrances, promotions, separations, and other changes, and leaves of absence; and records of applicants and of those who have resigned, with their reasons for leaving the service. It also maintains the accident records of the staff as required for the administration of the employees' compensation act; coöperates with the emergency and first-aid volunteer staff; and maintains rooming lists to aid employees in securing housing accommodations. This work is performed by a section chief and three office employees.

Purchase Section. The Purchase Section handles all proposals and requisitions for construction equipment and supplies covering the industrial, technical, and scientific needs of the Bureau; performs the routine work in connection with all purchases and travel orders; and receives, records, distributes, collects, prepares for payment, and passes to the finance section, all vouchers for such expenditures. In order to enable the staff to select and procure the latest types of scientific apparatus and grades of technical materials, the section maintains a library of 15,000 scientific and industrial catalogues, descriptive circulars, and price lists. It has an effective system for the prompt procurement of the latest issues of such technical supply literature. The section chief confers with the laboratory men in locating sources of such special supplies and equipment. The chief of the section is assisted by two office employees.

Property and Transportation Section. The Property and Transportation Section administers the accession, distribution, and accountability of property; keeps the records of the property both in the nature of equipment and of supplies; performs the work of receiving and shipping instruments and materials of all kinds, including the shipment of instruments tested; has general supervision of the special storerooms for the supply of chemicals and mechanical stores; and maintains a schedule of transportation service by motor truck for the movement of freight. The Bureau furnishes trucking facilities for all freight and general drayage for the entire Department of Commerce, thus saving the extra cost of private hauling. A perpetual inventory of stores maintained in this section enables the storeroom to keep standard supplies in stock and to avoid the accumulation of dead stock.

The personnel of the section consists of the section chief, eight office employees and six truck operators and chauffeurs.

Mails and Files Section. The functions of the Mails and Files Section are to handle and file communications received and sent out, about half of which are of sufficient importance to justify special card indexing. It compiles, maintains, and distributes a book of "Standard office practice," covering the clerical work of the Bureau, the book being based on regulations, special orders, and other authoritative sources. It maintains a complete system of collection and delivery of communications extending to about twenty separate buildings, and supervises communication facilities, including telephone, telegraph, elevator and messenger service. This section has a chief, five office employees, two telephone operators and six office apprentices and messengers.

Library. The technical library which is used for reference by members of the staff and by others, has about 28,000 volumes. In addition, it currently receives 646 periodicals, of which 415 are in English, 119 in German, sixty-eight in French, and forty-four in nine other languages. Over half of these periodicals are obtained by exchange. Of the 646 periodicals, 19 are classified as scientific and technical bibliography and abstracts; seventy-four general science, twenty-one physics, fifty-two closely related to physics, ten mathematical, seventy-three general engineering, eighty special fields of engineering, thirty-eight metallurgy, seventy-five electricity, telephony and radio, sixty chemistry and chemical technology, thirty textiles, paper, rubber and leather, and the remainder, miscellaneous or general technical subjects. The library is administered by an expert in physics, mathematics and library science. The library force consists of a librarian and an assistant.

Information Section. The Information Section prepares the "Technical News Bulletin," which is issued once a month and describes the progress of work in the laboratories, lists new publications, etc.; has charge of the official distribution of publications and reports covering tests of materials; answers general technical inquiries by mail and telephone, and routes specific inquiries to the proper section; prepares special reports and articles for the technical and popular press; and interviews general visitors. The work of the section is performed by a section chief and an assistant.

Division of Operation. This Division of Operation operates and maintains the power, heating and refrigerating plants; installs and repairs the electrical and plumbing equipment, and cares for buildings and grounds. Its functions include, under routine service, the heating, lighting, cleaning, maintaining, and guarding of all the buildings; operating two steam plants for furnishing high and low-pressure steam for laboratory use; manufacturing ice and circulating brine at low temperatures, cooling and circulating water for drinking and laboratory uses; generating, converting, and transmitting electric power from three substations at a dozen different voltages or frequencies; providing stationary and portable storage-battery service; providing high and low pressure air, gas, vacuum, and hot and cold water service; maintaining elevators; caring for lawns, shrubbery, paths, roads, and drainage systems, and propagating and caring for flowers; installing new equipment or making alterations to meet changing requirements; and furnishing every other service within the range of the equipment and ability of the personnel to aid the scientific and technical work of the Bureau. The division has no subordinate sections. Its work is performed by a chief of division, one office employee, and thirty-four mechanics and laborers.

Division of Construction. The Division of Construction has charge of the construction plants of the Bureau, comprising instrument and machine shops, wood working shops, a glass blowing shop, a glass grinding shop, a photographic shop, and construction stores.

There are no sections in this division. Its personnel consists of a chief of division, two clerks, and twenty-four mechanics.

Division of Weights and Measures. The Division of Weights and Measures concerns itself with all matters pertaining to standards of length, mass or weight, time, area, volume, density, and pressure. It is charged with the custody of the national standards of the United States and with the task of spreading abroad their influence and of carrying them to as great an extent as necessary into the scientific, industrial, and commercial life of the nation. The division is under the direction of two co-division chiefs. The office proper of the division chiefs includes also four office employees.

The division has nine sections, each dealing with one of the following subjects: Length, mass, time, capacity and density, gas measuring instruments, thermal expansivity, weights and measures laws administration, investigating and testing of scales, and gauge standardization.

Length Section. The functions of the Length Section comprise: Preservation and comparison of the national prototype meter and its copies; development of methods and apparatus for length measurement; comparison of state, municipal, and other standards of length with national standards; preparation of specifications for instruments and materials requiring linear dimensions of a definite and stated accuracy; tests of instruments and materials to determine conformity to specifications; miscellaneous measurements of length; and collection, compilation, and distribution of information regarding methods of length measurement. The working force of the section consists of four laboratory workers.

Mass Section. The duties of the Mass Section are similar to those of the preceding section with regard to length. They include custody of national standards of mass; testing standard weights and precise balances; and improvement of mass standards and of methods of weighing. Four laboratory employees perform this work.

Time Section. The Time Section includes: Test, certification of and researches on time-measuring devices; service on committees organized to improve construction; test, use and repair of time-measuring devices; and answering inquiries concerning time-measuring devices and related subjects. The work of the section is performed by two laboratory employees.

Capacity and Density Section. The work of the Capacity and Density Section comprises the testing of capacity and density apparatus; design, improvement, and calibration of special volumetric apparatus; determination of density and volumetric coefficients of liquids and the preparation of tables thereon; and assistance to manufacturers of apparatus by conference and correspondence. Six laboratory employees perform the work of this section.

Gas Measuring Instruments Section. The Gas Measuring Instruments Section makes tests of and conducts researches on gas-measuring instruments, and prepares publications on gas measuring instruments and methods. Its members serve on committees whose functions are to specify standards for the construction, testing and use of gas meters. The personnel of this section consists of four laboratory employees.

Thermal Expansivity Section. The scope of the Thermal Expansivity Section's work comprises experimental determination of thermal expansivity of solids; study of transformation regions when accompanied by length changes; determination of dimensional variations incident to heat treatment; ruling scales of and producing screws of high precision; and giving advice regarding the propriety of combining different materials in structures, apparatus, etc. This section employs three laboratory workers and an instrument maker.

Section of Weights and Measures Laws Administration. The Section of Weights and Measures Laws Administration coöperates with state and local weights and measures departments and with manufacturers of weighing and measuring devices in securing better utilization of standard weights and measures, and conducts investigations and surveys on matters pertaining to weights and measures. The work of this section is carried on by one laboratory worker.

Investigating and Testing of Scales Section. The duties of the Investigating and Testing of Scales Section comprise: Calibration and maintenance of accuracy of master track scales; investigation of railway track and of mine scales; calibration of test cars and of heavy weights; development of methods for heavy-capacity scales, and of specifications and tolerances and methods of tests for, and capacity rating of, master track, railroad track, and other heavy capacity scales, and of testing machines; and coöperation with railroads, weighing bureaus, and others on heavy-capacity scale and weighing problems. The personnel of this section consists of a laboratory worker and four inspectors of weights and measures.

Gauge Standardization Section. The Gauge Standardization Section determines dimensions of master, inspection, and working gauges used in interchangeable manufacture; develops and constructs apparatus for measuring or checking gauges, and manufactures gauges for experimental purposes; collects data on stock sizes, standard dimensions, and tolerances for common and metal shapes and machine elements; and coöperates with engineering committees or commissions engaged in standardizing sizes of and tolerances for machine elements. The working force of this section comprises six laboratory and six shop workers, and one office employee.

Electricity Division. The Electricity Division is concerned with all electrical problems that claim the Bureau's attention, including electrical standards of measurement, electrical constants, electrical properties of materials, and the performance of electrical properties of materials. It establishes, maintains, and compares fundamental electrical standards, and makes tests, and conducts researches in electricity and allied subjects. Its electrical work covers electrical units, standards, measuring instruments, and methods of measurement, including electromotive force, resistance, current, inductance, capacitance, conductivity, insulation, magnetic measurements, radio and telephonic communication, and properties and performance of electrical equipment, such as lamps and batteries. The division also makes tests and studies in radio-activity and X-ray measurements, and it coöperates with public service companies, public utilities' commissions and municipalities in dealing with other public utilities problems relating to safety engineering in various fields and to gas engineering. The personnel of the office of the chief of division consists of the chief of division, an assistant superintendent of buildings and equipment, five office employees, and three shop and construction employees.

The division has ten sections designated according to their respective functions as follows: Resistance measurements, inductance and capacitance, electrical measuring instruments, magnetic measurements, photometry and illuminating engineering, radio communication, electrolysis prevention, safety engineering, electrochemistry, and telephone service standards.

Resistance Measurements Section. The duties of the Resistance Measurements Section comprise: the establishment and maintenance of the ohm; development of resistance apparatus; galvanometer design; study of methods of resistance measurement; testing of resistance measuring standards and apparatus; investigation of electrical properties of conductors; standardization of conductor materials; and application of resistance methods. The work of this section is carried on by three laboratory employees.

Inductance and Capacitance Section. The Inductance and Capacitance Section has for its functions the establishment of fundamental standards of inductance and capacitance, and the maintenance of such working standards; the calibration of standards of other laboratories; investigation of methods of measurement;

measurement of the electric properties of insulators; and measurements on phenomena involving the determination of short-time intervals. The personnel of this Section consists of six laboratory employees and one shop, and one office employee.

Electric Measuring Instruments Section. The work of the Electric Measuring Instruments Section consists of the testing of electrical measuring instruments and accessories; maintenance and extension of standards and methods for measuring voltage, current, power, and energy; research on problems related to commercial electrical measurements; development of specifications for electrical measurements; and miscellaneous electrical tests and investigations. This work is performed by eleven laboratory employees and one shop employee.

Magnetic Measurements Section. The Magnetic Measurements Section deals with the development and maintenance of methods and apparatus for the determination of the magnetic properties of materials; making tests of the magnetic properties of materials and other magnetic effects; and correlating magnetic properties with other physical properties of materials. The personnel of this section consists of three laboratory employees and one shop employee.

Photometry and Illuminating Engineering Section. The functions of the Photometry and Illuminating Engineering Section comprise: Maintenance of fundamental standards of candlepower; calibration of standard lamps and of photometric instruments; research on methods of measuring light; development of photometric instruments; inspection and testing of lamps purchased by the government; investigation of characteristics of lamps; formulation of lamp specifications; tests of lighting fixtures and accessories; investigations of motor vehicle lighting; and consultation service to government departments on lighting problems. Ten laboratory employees are engaged in this work.

Radio Communication Section. The work of the Radio Communication Section comprises the establishment of radio standards; the testing of radio instruments and devices; the development of methods of radio measurement; formulation of specifications for radio equipment; study of wave phenomena; survey of interference; electron tube research; development of radio devices; application of radio methods; coöperation with other governmental services; and supplying of radio information. The personnel of this section consists of twelve laboratory, and three radio-physics laboratory employees, and three shop, and two office employees.

Electrolysis Prevention Section. The Electrolysis Prevention Section conducts field research on electrolysis testing and mitigation; investigation of corrosive action of soils on pipes and cables, and methods of reducing damage from this cause; and the development of electric strain gauges. Five laboratory employees, one shop employee, and one laborer constitute the personnel of this section.

Safety Engineering Section. The Safety Engineering Section concerns itself not only with electrical, but also with other safety engineering as well. Its work consists of the preparation of safety standards and the investigation of materials and apparatus incidental to their establishment; coöperation with state and municipal officials, engineering, insurance, and other associations in the preparation, interpretation, and application of safety standards; and the preparation of publications bearing on the application of safety standards. This work is performed by one office employee and five laboratory workers.

Electrochemistry Section. The work of the Electrochemistry Section is mainly concerned with batteries. It investigates the factors affecting their performance; tests primary and storage batteries and materials; formulates specifications and standard methods of testing batteries, and coöperates with other organizations in their standardization. The section is also concerned with the study and comparative testing of rectifiers, research on single potential measurements, and investigation of the silver voltmeter. Five laboratory workers are employed in this section.

Telephone Service Standards Section. The functions of the Telephone Service Standards Section include the determination of standard measures for quantity and quality of telephone service; the furnishing of information to regulatory bodies; serving as consulting telephone engineers to the national and state governments; investigation of the mathematical theory of submarine cable telegraphy; establishment and maintenance of the standard of electromotive force; and testing standard cells. Four laboratory employees are engaged in this work.

Division of Heat and Power. The Division of Heat and Power deals with heat standards, heat constants, and researches on quality and performance where heat measurement is the essential or predominating factor. Its functions consist of the maintenance of standards in the field of heat and temperature measurements; the establishment of basic data on the thermal properties of matter, and on the effects of temperature on materials of construction; and the investigation of materials and processes involved in the production of power by heat engines. The division chief has four clerical employees in his office. It is subdivided into six sections according to the nature of their functions, as follows: Thermometry, pyrometry, heat measurement, cryogenic laboratory, fire resistance, and automotive power plants.

Thermometry Section. The functions of the Thermometry Section include the standardization of the temperature scale below 500° centigrade; testing thermometers; and making miscellaneous tests. Eight laboratory workers are employed in this section.

Pyrometry Section. The Pyrometry Section deals with the standardization of the temperature scale above 500° centigrade; tests pyrometers; develops pyrometers and methods; and investigates properties of materials at high temperatures. The work of the section is performed by four laboratory employees.

Heat Measurements Section. The work of the Heat Measurements Section comprises tests and researches in calorimetry, thermodynamic properties of fluids, and heat transfer. Eight laboratory workers and two shop workers are employed in this section.

Cryogenic Laboratory Section. The Cryogenic Laboratory is used for the production of low temperatures for general use, comprising a liquid air plant, a liquid hydrogen plant, a liquid helium plant, and a carbon dioxide refrigerating plant. Two laboratory employees carry on the work of this section.

Fire Resistance Section. The functions of the Fire Resistance Section comprise research on fire resistive properties of building materials, construction, and devices; the standardization of fire tests; and the development of standards of practice in the preparation of fire regulations and specifications. The personnel of this section consists of nine laboratory, and four shop employees, and two laborers.

Automotive Power Plants Section. The scope of the work of the Automotive Power Plants Section covers the investigation of scientific and technical problems connected with the design, operation, and testing of internal combustion engines and their accessories as applied to automotive purposes, and the investigation of qualities and characteristics of fuels and lubricants. This section employs twenty laboratory, and thirteen shop employees, and two laborers.

Optics Division. Questions of light and vision enter into standards of all kinds, hence the Bureau has organized an optics division, in which are brought together, experts in spectroscopy, polarimetry (used in sugar analysis), color measurement, the principles of optical measurements, the measurement of the optical properties of materials, and investigation of atomic and molecular structure. The chief of this division has two office assistants.

The work is distributed among eight sections, namely: Spectroscopy, polarimetry; colorimetry; refractometry and optical instruments; atomic physics; radium and X-rays; photographic technology; interferometry.

Spectroscopy Section. The functions of this Spectroscopy Section cover: Determination of standard wave lengths; description of emission spectra of the chemical elements; analysis of complex spectra; spectrochemical research and tests; preparation of spectrum tubes; cathodic deposition of metal mirrors; photographic emulsion investigations; photochemical study of light-sensitive materials; and tests of photosensitizing dyes. Five laboratory employees carry on the work of this section.

Polarimetry Section. The Polarimetry Section is chiefly concerned with sugar tests and researches, including physiochemical properties of common sugars; properties and structure of rare sugars and associated compounds; analysis of sugars and sugar products; color and decolorization in technical sugar products; and standardization of practice in sugar technology. The section also undertakes studies concerning magneto and electro optics, natural optical activity and double refraction. Fifteen laboratory employees, and one shop, and one office employee constitute the personnel of this section.

Colorimetry Section. The work of the Colorimetry Section covers the specification and standardization of colors, including determination of the color characteristics of natural and artificial sources of light on the properties of materials which determine their color; also the study of phenomena and laws of color vision. Seven laboratory workers and one shop employee perform this work.

Optical Instruments Section. The functions of the Optical Instruments Section consist of the testing of optical glass; the design and testing of optical systems; the design and testing of optical instruments; and the construction of optical components. This work is carried on by six laboratory, and five shop employees.

Radiometry Section. The Radiometry Section is concerned with the determination of the fundamental constants of thermal radiation; development of instruments and methods of radiometry; investigation of the emissive, reflective, and absorptive properties of materials for thermal radiation; and maintenance of glasses for protecting the eyes from injurious thermal radiation. Two laboratory workers are employed in this Section.

Atomic Physics, Radium and X-Ray Section. The Atomic Physics, Radium and X-Ray Section deals with the investigation of atomic and molecular structure by measurements of the energy required for the formation of ions, and the radiation consequent upon their recombination; determination of physical constants and tests of radioactive substances; investigation and application of X-rays, and study of means for avoiding their harmful effects; and furnishing information to the public on radium and of radium preparations. The work of the section is performed by eight laboratory workers and one shop employee.

Photographic Technology Section. The work of the Photographic Technology Section consists of tests and researches in sensitometry; investigation of illumination in photography; photomechanical processes; and work in applied photography. The personnel of the section consists of six laboratory employees.

Interferometry Section. The functions of the Interferometry Section consist of work in the most precise linear measurements; calibration of end standards; line standards; ruling of precise scales; determinations of index of refraction; dimensional changes of materials; plane surfaces; and accurate measurements of the size of miscellaneous small objects. Two laboratory employees constitute the personnel of this section.

Division of Chemistry. The Division of Chemistry has general supervision of all the chemical work of the Bureau. In practically all questions of standardization or research, the purity of the materials involved is an important factor, and much of the work in the field of chemistry done in other divisions is supervised by this division. This includes the investigation of the chemical composition and purity of materials; studies of chemical properties and constants; researches in connection with methods of analysis; and the preparation of specifications for technical materials for other departments of the government and for industrial and scientific laboratories. This division constantly acts as consultant to other agencies of the government and to the general public in all sorts of technical questions relating to the materials mentioned below. The division chief has the assistance of six office employees.

There are seven sections: Paint, varnish, and bituminous materials; detergents, cements, and corrosion; miscellaneous organic materials; inorganic analysis and standard samples; platinum metals and reagents; electrochemistry; and gas chemistry.

Section of Paint, Varnishes, and Bituminous Materials. The work of the Section of Paint, Varnishes, and Bituminous Materials consists of tests and researches on pigments, drying oils, volatile solvents, resins, bitumens, paint, varnish, bituminous roofing, waterproofing, and related materials. Eleven laboratory workers are employed in this section.

Section of Detergents, Cement, Corrosion, etc. The Section of Detergents, Cement, Corrosion, etc., deals with detergents, polishes, waxes, non-drying oils, coated metals, industrial waters, boiler compounds, fire-extinguishing liquids, cement, gypsum, lime, clay, sand, and miscellaneous materials. The personnel of the section consists of eight laboratory employees.

Section of Rubber, Lubricants, Textiles, Inks, etc. The materials chemically dealt with in the section of Rubber, Lubricants, Textiles, Inks, etc., are rubber, airplane dopes, balloon fabrics, dyes, inks, typewriter ribbons, carbon paper, adhesives, textiles and lubricants. The work of this section is carried on by eleven laboratory employees.

Section of Metal and Ore Analysis and Standard Samples. The Section of Metal and Ore Analysis deals with ores, cast irons, plain carbon steels, alloy steels, brasses, bronzes and bearing metals, melting-point standards, sieve standards, and pure chemicals. The personnel of the section consists of nine laboratory workers, and one shop, and one office employee.

Section of Platinum Metals and Reagents. The work of the Section of Platinum Metals and Reagents deals with platinum metals, covering methods of separation, methods of purification, and methods of analysis; routine preparation of pure materials; routine analysis of platinum-bearing materials; reagents, covering methods for testing, and routine testing; preparation of pure substances; and supervision of chemical storeroom. The work of this section is carried on by four laboratory workers and one office employee.

Electrochemistry Section. The Electrochemistry Section deals with electrodeposition of metals, including structure, composition, and use of anodes, analysis, properties, and behavior of solutions, structure and properties of deposits, protective value of plated coatings, and industrial and federal applications; and electrochemical measurements covering conductivity of solutions, hydrogen ion concentration, and electrode potentials. Five laboratory workers are employed in this section.

Gas Chemistry Section. The Gas Chemistry Section deals with fuel gases, including the design and performance of domestic appliances, industrial gases, and pure gases; gas reactions, including physical chemistry (equilibria, reaction velocity, etc.), industrial reactions (engineering problems, etc.); methods of producing gases, covering laboratory production of gases for experimentation, and commercial production; gas analysis, covering laboratory and reference methods, automatic methods; process control by analysis; utilization of gases; and balloon fabrics. Ten laboratory workers and two shop employees carry on the work of this section.

Division of Mechanics and Sound. The functions of the Division of Mechanics and Sound comprise investigations relating to mechanics, sound, and properties of matter, including hydrodynamics, aerodynamics, aircraft, and engineering instrument research, and the standardization of mechanical appliances. The personnel of the office proper of the division chief consists of an office assistant, four laboratory workers, and one shop employee.

It includes five sections dealing with: engineering instruments and mechanical appliances; sound measurements; aeronautic instruments; aerodynamical physics; and engineering mechanics.

Section of Engineering Instruments and Mechanical Appliances. The Section of Engineering Instruments and Mechanical Appliances has the following functions: Study of the theory, characteristics and limitations of engineering instruments; their calibration; the formulation of standards of their performance; and their development and improvement; investigation of groups of similar commercial appliances for the purpose of establishing standards of performance; the development of test methods and apparatus and of improvement of methods of calibration; the investigation of new appliances of engineering importance; and the testing of mechanical appliances. Five laboratory workers and one shop employee carry on the work of the section.

Sound Section. The work of the Sound Section covers: sound sources, sound receivers, acoustic properties of materials, frequency standardization, oscillography, chronography, and ballistic measurements. The section personnel consists of five laboratory and two shop workers, one office employee, and one laborer.

Aeronautic Instruments Section. The Aeronautic Instruments Section conducts researches on errors of aeronautical instruments, the theory of their performance, temperature compensation, etc.; investigations of aerial navigation methods; determining altitude for record flights; development of testing methods and preparation of specifications for aeronautic instruments; and development of altitude, rate-of-climb, air-speed, navigating, and other aeronautic instruments, and of salvage methods for aeronautic instruments. Nine laboratory employees, three shop employees, and one office employee carry on the work of the section.

Aerodynamical Physics Section. The work of the Aerodynamical Physics Section covers: The measurement of the resistance of the air to the motion of bodies relative to it, comprising measurement of forces and moments on air foils, airplane and airship models, aircraft bombs and bomb models, etc.; measurement of the damping of oscillations of bombs, airship models, etc.; measurement of the distribution of pressure over airship hulls, airship fins, projectiles, etc.; and measurement of wind pressure on structures; and calibration of instruments for use in air-streams of speed ranging from fifteen to 150 miles per hour. This work is performed by six laboratory employees.

Engineering Mechanics Section. The Section of Engineering Mechanics conducts special experimental and theoretical researches and problems relating to performance standards of mechanical appliances. It concerns itself with the measurement of the resistance of fabricated structural units under tensile, compressive, and torsional stresses; the determination of physical properties of new material; the design and testing of structures; and the study of testing apparatus and testing methods. The personnel of this section consists of fourteen laboratory employees, three shop employees, a laborer, and an office employee.

Division of Structural, Engineering, and Miscellaneous Materials. The functions of the Division of Structural, Engineering and Miscellaneous Materials comprise the testing, investigation, uses, design, and fabrication of structural, engineering, and miscellaneous materials; the study of the processes by which they are manufactured; the improvement of the present and the development of new methods of testing these materials; and the establishment of standards covering their manufacture and use. It is preëminently the industrial division of the Bureau, its work being carried on in close coöperation with the various industries of the country.

The office force of the division comprises the chief, an assistant chief, and two office employees.

The division comprises five sections, each of which concerns itself with a group of related materials, namely, cement, concrete, and stone; leather and rubber; textiles; paper; and lime, gypsum, and sand-lime brick.

Cement, Sand and Stone Section. The functions of the Cement, Sand, and Stone Section comprise inspection and testing of cement for government departments; researches in cement, concrete, and building stones; and the development of specifications and methods of tests for these materials. The section also maintains laboratories in San Francisco and Denver, and in Northampton, Pennsylvania. The personnel consists of sixteen laboratory employees, one office employee, and four laborers; also thirteen field employees, all of whom are laboratory workers.

Rubber, Leather, etc., Section. The Rubber, Leather, etc., Section concerns itself with standard test methods, the preparation of specifications, and the testing and standardization of rubber and leather materials and manufactures; the investigation of industrial processes in rubber and leather production; and similar work on related materials. Sixteen laboratory workers, and one shop and one office employee carry out the work of this section.

Textiles Section. The work of the Textiles Section covers the study of raw textile fabrics; manufacturing processes; study of uses; methods of chemical, physical and microscopic testing of textiles, their development and application; and the laundering, pressing, storing, and cleaning of textile products. This section has a force of ten laboratory workers and one office employee.

Paper Section. The Paper Section concerns itself with the physical and chemical testing of paper; microscopy and photomicrography; study of special raw materials and of processes of manufacture; manufacture of special papers; and preparation of standard specifications. The work of the section is carried on by nine laboratory employees, and one office employee.

Lime, Gypsum, etc., Section. The Lime, Gypsum, etc., Section is concerned with standards of quality, improvement of manufacture, and use of lime, gypsum, and sand-lime brick; improvement of new products; and the development of new uses of these materials. Five laboratory workers and one office employee carry on the work of this section.

Metallurgy Division. The Metallurgy Division concerns itself with research, investigation, and testing of metals and alloys, except built-up structures and the processes of extracting metals from their ores. Its functions include the production of metals and alloys, both of the highest attainable purity and of commercial grades; the preparation and study of auxiliary metallurgical products; the development of instruments, apparatus, and manufacturing appliances for metallurgical processes, research, and testing; the formulation and maintenance of standards and specifications of interest to metallurgists; the determination of metallurgical constants and properties; the determination of the causes of failure and the study of the improvement of metal products; and the development of economical metal substitutes.

The Metallurgy Division has equipment for and carries on metallographic examinations of metals; thermal analyses; various heat treatments; various operations for hot and cold working of metals; the usual foundry operations of molding and casting ferrous and non-ferrous metals; and other metallurgical processes. The office proper of the chief of division includes the chief, two laboratory workers, three office employees, and two shop workers.

The division comprises five sections, devoted respectively to optical metallurgy, thermal metallurgy, mechanical metallurgy, chemical metallurgy, and experimental foundry.

Optical Metallurgy Section. The work of the Optical Metallurgy Section comprises: Identification of metallurgical constituents, unknown alloys, heat treatment, and mechanical history; constitution; causes of failure; etching reagents; metallographic apparatus and metallographic standards; corrosion and its prevention; coated metals; photomicrographs.

The work of the section is carried on by nine laboratory workers and one shop employee.

Thermal Metallurgy Section. The Thermal Metallurgy Section concerns itself with: Thermal analysis, comprising location of critical points, survey of heat treatment, and new alloys; heat treatment, including annealing and normalizing, hardening and tempering, cementation, and investigation of new alloys; high temperature properties of metals. Seven laboratory workers and two shop employees carry on the work of this section.

Mechanical Metallurgy Section. The functions of the Mechanical Metallurgy Section comprise: Working of metals, such as forging, rolling, drawing, welding, and soldering; study of railroad materials, including causes of failure, materials and specifications, rails, wheels, axles, etc.; study of miscellaneous properties, such as bearing metals, fusible plugs, miscellaneous tests, specifications, and nomenclature; consideration of manufacturing appliances and processes. The section employs five laboratory workers and one laborer.

Chemical Metallurgy Section. The Chemical Metallurgy Section devotes itself to the preparation of pure metals and alloys, including a study of the influence of chemical composition on the properties of metals, the development of new alloys, and working metals of high purity; the study of gases in metals, including development of methods of analyses, influence of gases on physical properties, deoxidization of metals, and the solubility of gases in metals; study of metallurgical auxiliary materials, such as refractories, slags, ferrous alloys and deodorizers, and metal-melting furnaces; preparation of chemical metallurgy standards. Six laboratory workers carry on the work of this section.

Experimental Foundry. The Experimental Foundry carries on experimental work in the usual foundry operations of molding and casting ferrous and non-ferrous metals. The foundry serves the whole Bureau in the making of castings of all ferrous and non-ferrous alloys for the shops to use in making up special apparatus. It also does a limited amount of rush or special work for other government departments. Another service to the Bureau is the melting and working of platinum and its alloys for use within the Bureau as thermocouples and for the other purposes for which these alloys are required in scientific work. The foundry employs six laboratory workers and one shop employee.

Ceramics Division. The Ceramics Division deals with standards of quality, methods of test, and specifications for ceramic materials and products; the study of problems relating to the preparation and utilization of ceramic materials and the manufacture of ceramic products; the elimination of waste by supplying definite guides to purchasers and by obtaining and disseminating to manufacturers scientific information of assistance in the improvement of products and in increasing the efficiency of methods. The work of this division is supervised by the chief of the Division of Structural Engineering and his assistant. One office employee works under their immediate direction in this division.

The division comprises four sections devoted respectively to work in pottery and fine ceramics, optical glass, clay products and refractories, and enameled metals.

Pottery and Fine Ceramics Section. The Pottery and Fine Ceramics Section deals with that part of the ceramic work of the Bureau which relates to tableware of earthenware and porcelain, architectural terra cotta, building tile, art pottery, chemical and high temperature porcelain, and stone ware. Its work consists of studying the effect on the finished product of the raw materials used, the manufacturing processes, and the burning conditions;

the development of chemical, physical, and petrographic tests; and the establishment of standards of quality and service. This work is performed by six laboratory workers and two shop employees.

Optical Glass Section. The functions of the Optical Glass Section are to study the raw materials for glass and glass containers, and the processes of their manufacture; the physical properties and service conditions of glass containers; the study of the physical properties of optical and sheet glass and of glass table ware; and the annealing and testing of glass and the preparation of specifications therefor. This section employs eight laboratory employees and one laborer.

Clay Products and Refractories Section. The Clay Products and Refractories Section deals with heavy clay products such as brick, hollow tile, and drain tile; fire-clay, silica, magnesite, chrome, and other brick; and glass tank blocks, and glass pots. Its work comprises investigations of raw materials, manufacturing processes, and commercial uses of these commodities; and the development of standards of tests, quality, and use. Six laboratory workers, one shop employee, and one laborer are employed in this section.

Enameled Metals Section. The Enameled Metals Section concerns itself with the enameling of ferrous and non-ferrous metals, its work consisting of studies of the effect on the finished ware, of the raw materials used, the composition, the melting, and the metal surface. It also develops standards of quality and test methods. This work is carried on by two laboratory employees.

Division of Simplified Practice. The functions of the Division of Simplified Practice are to coöperate with American industries in furthering the elimination of waste in commerce and industry through reduction in the number of sizes and types of standard products, the abandonment of useless varieties, and the concentration of the attention of manufacturers upon articles of the greatest interchangeability. The personnel of this division consists of a chief of division, five simplification specialists, and eleven office employees.

Division of Building and Housing. The chief aim of the Division of Building and Housing is to assist the construction industry in providing the American people with better construction at reduced cost. Its functions include the gathering and distributing of scientific, practical, statistical, and other information tending to encourage, cheapen, and improve construction and housing; investigations for use in framing local building and plumbing codes, and dealing with problems connected with city zoning; collecting, analyzing, and distributing information on the prices, production, consumption, and stocks of building materials and on building activity, special attention being given to factors bearing on the housing problem. The division's work is purely advisory and educational. Results are being accomplished largely through coöperation with state and local authorities and with private trade associations, professional societies, and civic organizations. The work of the division is carried on by a chief of division, five technical assistants and thirteen office employees.

Coöperating Bodies. In addition to the paid officers and employees of the Bureau of Standards, there are private individuals and committees representing scientific and industrial organizations who render material service in connection with the Bureau's work. These are the Research Associates, the Visiting Committee and the Advisory Committees.

Research Associates. There are about fifty persons representing twenty-seven different organizations, called research associates who are stationed at the Bureau by trade associations and others, working on fundamental problems on which the industries want specific answers. These associates have the use of the laboratories, and they work with the experts of the Bureau under the Bureau's direction.

Board of Visitors. The organic act of the Bureau[1] provides for the appointment, by the Secretary of Commerce, of a Visiting Committee of five members to consist of prominent men in the various interests involved and not in the employ of the government, who are to visit the Bureau at least once a year and report to the Secretary of Commerce, upon the efficiency of its scientific work and the condition of its equipment. The members serve without pay.

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[1] See page 249.

Advisory Committees. There are eighty-two advisory committees which consult with the Bureau on different subjects. These committees are all made up of representatives from the industries, appointed by the industries, or by technical, engineering, or scientific societies. The Bureau sometimes adds one or two members to a committee, but in general they are appointed to represent the industry or the science concerned. They come at their own expense to Washington and receive no compensation from the Bureau. The first of these committees to be appointed has been meeting semi-annually for fourteen years. The meetings are always well attended.

Following is a list of the advisory committees to the Bureau of Standards, in January, 1924, the figures indicating the number of persons comprising their membership:

ADVISORY COMMITTEES, BUREAU OF STANDARDS (82).

Visiting committee (5).
Standardization of builders' hardware (19).
Wood screw conference (8).
Executive committee, state utility commission of engineers (4).
Standardization of hardware for hollow metal doors (36).
Rubber Heel Club of America (3).
Dictionary of specifications (13).
Electric Manufacturing Council (5).
Wire rope (10).
Elevator code (29).
Aeronautical safety code (30).
Electrical safety code (60).
Research subcommittee of American committee on electrolysis (7).
Safety code on logging and sawmill operations (28).
National safety code for the protection of the heads and eyes of industrial workers (23).
Safety code for lightning protection (27).
National Screw Thread Commission (10).
Executive committee of the annual conference on weights and measures of the United States (23).
Committee for the standardization and unification of screw threads (sectional committee under the American Engineering Standards Committee), (14).
Sectional committee on standardization of plain limit gages for general engineering work (19).

Joint conference on specifications for hand operated grain hopper scales (8).

Committee on specifications and tolerances of the annual conference on weights and measures (3).

Subcommittee on railroad track scales of the yards and terminals committee, American Railway Engineering Association (6).

Subcommittee on outline of work for ensuing year, yards and terminals committee, American Railway Engineering Association (4).

Committee on weighing of the American Railway Association (5).

Horological Institute of America (8).

Fuel investigation (4).

Oil acidity (7).

Refrigeration problems (5).

Fire tests of hollowing building tile (5).

Fire tests of brick walls (5).

Fire tests of roofing materials (6).

Specifications and tests of insulated safes (11).

Fire tests of light interior partitions (9).

Petroleum testing methods and specifications for petroleum and its products (8).

Committee on thermal expansion of petroleum oils (3).

Research committee of American Society of Mechanical Engineers (5).

Dye works (5).

Code on colors for traffic signals (35).

Soap specifications (3).

Electroplating (4).

Gas engineering (16).

Gas safety code appointed by American Gas Association (36).

Oxychloride cement (2).

Textile investigations, main advisory committee (17).

Wool committee (8).

Tent and awning duck committee (9).

Cordage committee (7).

Hoisery committee (5).

Wool blanket technical committee (3).

Cotton committee on research and standardization (6).

Cotton duck committee (3).

Silk committee on research and standardization (6).

Cotton thread committee (3).

Knit underwear standardization committee (24).

Shade cloth committee (7).

Sole leather (6).

Leather belting (4).

Paper (12).

Paper standardization (3).
Simplification of sizes and qualities of paper (7).
Rubber products (5).
Investigation of phosphorus and sulphur in steel (13).
Gage steel committee (23).
Ferrous alloys (17).
Transverse fissures in rails (11).
Non-ferrous alloys (16).
Steel wheels (7).
Chilled iron car wheels (2).
American Foundrymen's Association (4).
Cast iron for enameling purposes (5).
Warpage of sheet steel and iron in the enameling process (8).
Enameled kitchenware (1).
Wall tile (1).
Pottery (9).
Milk bottle standardization (3).
Specifications for sheet glass (12).
The National Terra Cotta Society (8).
Specifications for refractories (12).
Brick and tile (4).
Plastering (18).
National Terra Cotta Society (5).
Window and plate glass specifications (13).
Glass container (5).
Glass research (3).
National Lime Association (3).
Steam tables (1).
Cement (5).

As an illustration of what these committees actually meet for, the following list is given of the conferences held at the Bureau in the nine months from March 19 to December 12, 1923:[2]

March 19-20: Visiting committee.

March 19: Conference on standardization of butts.

March 20: Radio standardization conference at Department of Commerce.

March 20: Conference on standardization of flush and surface bolts.

March 26: Federal specifications board technical committee on chinaware, stoneware, and glassware.

March 26: Conference on corrugated zinc roofing.

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[2] Committee on Appropriations, Department of Commerce Appropriation Bill, 1925, Hearings, 1925, 268 cong. 1 sess., pp. 227-228.

March 28: Federal specifications board technical committee on textiles.

April 11: Federal specifications board technical committee on brick and building tile.

April 11: Federal specifications board technical committee on textiles.

April 13: Advisory committee on non-ferrous metals.

April 20: American Society for Testing Materials committee on consistency.

April 20-21: American Physical Society and Instrument Makers' Association.

April 25: Federal specifications board technical committee on textiles.

May 4: Federal specifications board technical committee on cement, lime, and plaster.

May 7: Committee on standardization of locks and lock trim.

May 7: Federal specifications technical committee on rubber supplies for hospitals.

May 9: Federal specifications board technical committee on textiles.

May 18: Advisory committee on ferrous metals, and metals committee of Federal specification board.

May 18: Federal specifications board technical committee on cement, lime, and plaster.

May 21-24: Annual weights and measures conference.

May 21: Committee on coöperation of electrical manufacturers council.

May 25: Conference of State purchasing agents on commodity specifications.

May 25: Sectional committee on aeronautical safety code.

May 24: Subcommittee on lighter-than-air craft of sectional committee on aeronautical safety code.

June 1: Advisory committee on research and standardization for textile industry.

June 11: Conference on specifications dictionary at department.

June 12: Meeting members of dye committee of dye division, American Chemical Society.

June 15: Committee on transverse fissures in rails.

June 16: Advisory committee on non-destructive testing of wire rope.

June 19: General conference on standardization of paper.

June 26: Meeting of National Screw Thread Commission.

July 10: Subcommittee on chinaware, Federal Specifications Board, with committee of the vitrified chinaware manufacturers.

July 26: Committee on standardization of knit goods.

July 27: Federal Specifications Board technical committee on cement, lime, and plaster.

August 2: Federal Specifications Board technical committee on packing specifications.

August 6: Federal Specifications Board technical committee on metals.

August 15: Conference on standardization of tin plate.

October 18: Federal Specifications Board technical committee on rubber hospital supplies.

October 20: American Society for Testing Materials committee on hollow tile specifications.

October 22: General conference on thermal conductivity of walls.

October 22: American Gas Association committee on gas safety code, and gas appliance manufacturers.

October 23-24: American Society for Testing Materials committee on gypsum standards.

October 23: Federal Specifications Board technical committee on refractories.

October 24: Federal Specifications Board technical committee on leather goods.

October 24: Dictionary of Specifications Advisory Board at Department of commerce.

October 31: Federal Specifications Board technical committee on textiles.

November 5: Federal Specifications Board technical committee on inks and typewriter ribbons.

November 8: Federal Specifications Board technical committee on brick.

November 9: Conference on uniform classification of iron and steel scrap.

November 14-15: National Screw Thread Commission at Bureau.

November-16: Advisory committee on non-ferrous metals.

November 16-17: Research Advisory Committee on electroplating.

November 21: Federal Specifications Board technical committee on textiles.

November 27: Federal Specifications Board technical committee on packing.

December 5: United States Potters' Association annual meeting at Bureau.

December 6: Annual meeting of American Institute of Chemical Engineers at Bureau.

APPENDIX 1

OUTLINE OF ORGANIZATION

Explanatory Note

The Outlines of Organization in this series of monographs have for their purpose to make known in detail the organization and personnel possessed by the several services of the national government to which they relate. They have been prepared in accordance with the plan followed by the President's Commission on Economy and Efficiency in the preparation of its outlines of the organization of the United States government.[1] They differ from those outlines, however, in that whereas the Commission's report showed only organization units, the presentation herein has been carried far enough to show the personnel embraced in each organization unit.

These outlines are of value not merely as an effective means of making known the organization of the several services. If kept revised to date by the services, they constitute exceedingly important tools of administration. They permit the directing personnel to see at a glance the organization and personnel at their disposition. They establish definitely the line of administrative authority and enable each employee to know his place in the system. They furnish the essential basis for making plans for determining costs by organization division and subdivision. They afford the data for a consideration of the problem of classifying and standardizing personnel and compensation. Collectively, they make it possible to determine the number and location of organization divisions of any particular kind, as, for example, laboratories, libraries, blue-print rooms, or any other kind of plant possessed by the national government, to what services they are attached and where they are located, or to determine what services are maintaining stations at any city or point in the United States. The Institute hopes that upon the completion of the present series, it will be able to prepare a complete classified statement of the technical and other facilities at the disposal of the government. The present monographs will then furnish the details regarding the organization, equipment, and work of the institution so listed and classified.

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[1] House Doc. 458, 62d Congress, 2d session, 1912, 2 vols.

OUTLINE OF ORGANIZATION

BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
MAY 15, 1925

Organization Units: *Classes of Employees*	*Number*	*Annual Salary Rate*
1. Office of the Director		
Director	1	$7,500
Assistant Director	1	5,400
Secretary	1	2,500
Office Employee	1	600
Technical Employee, Standardization of Specifications	2	5,200
	1	4,200
Office Employee, Standardization of Specifications	1	2,100
	1	2,000
	1	1,560
	3	1,500
	1	1,320
	1	1,140
2. The Office (Administration Division)		
Chief Office Division	1	3,800
Office Employee	1	2,500
	1	2,400
1. Finance Section		
Section Chief	1	3,300
Office Employee	1	1,980
	2	2,040
	1	1,860
	1	1,680
2. Personnel Section		
Section Chief	1	3,000
Office Employee	1	2,100
	1	1,680
	1	1,500
3. Purchase Section		
Section Chief	1	2,600
Office Employee	1	1,860
	1	1,680

4. Property and Transportation Section		
Section Chief	1	2,800
Office Employee	1	1,860
	3	1,680
	2	1,440
	1	1,380
	1	1,140
Truck Operator and Chauffeur	1	1,260
	1	1,200
	1	1,140
	1	1,080
	2	1,020
5. Mail and Files Section		
Section Chief	1	2,500
Office Employee	1	2,000
	1	1,560
	1	1,440
	2	1,140
Telephone Operator	1	1,380
	1	1,140
Office Apprentices and Messengers	1	900
	3	720
	2	600
6. Library		
Librarian	1	3,000
Library Assistant	1	1,680
7. Information Section		
Section Chief	1	3,000
Assistant	1	2,100
3. Division of Operation		
Chief of Division	1	3,800
Office Employee	1	2,100
Mechanics and Laborers	1	2,700
	2	2,200
	1	2,100
	1	2,000
	4	1,860
	1	1,800
	2	1,680
	5	1,500
	1	1,260
	2	1,200
	2	1,140
	11	1,020
	1	900

4. Division of Construction		
Chief of Division	1	3,300
Mechanic	1	2,400
	1	2,300
	1	2,200
	1	2,100
	2	2,040
	1	1,980
	1	1,920
	1	1,860
	2	1,740
	1	1,680
	1	1,560
	7	1,500
	1	960
	3	900
Clerk	1	1,560
	1	1,380
5. Division of Weights and Measures		
Co-Division Chiefs	2	5,200
Office Employee	1	2,700
	1	2,100
	1	1,680
	1	1,440
1. Length Section		
Laboratory Employee	1	3,000
	1	2,400
	1	2,100
	1	1,860
2. Mass Section		
Laboratory Employee	1	3,000
	3	1,860
3. Time Section		
Laboratory Employee	1	2,500
	1	960
4. Capacity and Density Section		
Laboratory Employee	1	3,000
	1	2,100
	1	1,860
	1	1,680
	1	1,500
	1	1,140
5. Gas Measuring Instruments Section		
Laboratory Employee	1	3,000
	2	2,100
	1	1,320

6. Thermal Expansivity Section		
Laboratory Employee	1	4,200
	1	3,000
	1	1,380
Instrument Maker	1	2,400
7. Section of Weights and Measures Laws Administration		
Laboratory Employee	1	3,800
8. Investigation and Testing of Scales Section		
Laboratory Employee	1	3,800
Inspector of Weights and Measures	1	2,500
	1	2,100
	1	2,000
	1	1,680
9. Gauge Standardization Section		
Laboratory Employee	1	3,000
	1	2,800
	1	2,100
	2	1,860
	1	1,140
Shop Employee	1	2,400
	1	2,200
	3	2,100
	1	1,920
Office Employee	1	1,140
6. Electricity Division		
Chief of Division	1	5,400
Office Employee	2	1,860
	1	1,680
	1	1,560
	1	1,500
Assistant Superintendent, Building and Equipment	1	2,300
Shop and Construction Employee, Building and Equipment	1	1,740
	2	1,140
Office Apprentice	1	960
1. Resistance Measurements Section		
Laboratory Employee	1	3,800
	1	1,860
	1	1,560
2. Inductance and Capacitance Section		
Laboratory Employee	1	5,200
	1	3,800
	2	3,000
	1	2,400
	1	1,860

Shop Employee	1	2,600
Office Employee	1	1,680
3. Electric Measuring Instruments Section		
Laboratory Employee	1	5,200
	1	4,400
	1	2,700
	1	2,600
	2	2,400
	3	1,860
	1	1,500
	1	1,320
Shop Employee	1	2,100
4. Magnetic Measurements Section		
Laboratory Employee	1	3,800
	1	2,400
	1	1,560
Shop Employee	1	1,920
5. Photometry and Illuminating Engineering Section		
Laboratory Employee	1	5,200
	1	3,600
	1	2,400
	3	1,860
	1	1,680
	1	1,320
	2	1,140
6. Radio Communication Section		
Laboratory Employee	1	5,200
	1	3,800
	2	3,300
	1	2,900
	3	2,400
	1	2,100
	1	1,560
	2	1,320
Laboratory Employee, Radio Physics	1	4,000
	1	2,400
	1	1,860
Shop Employee	1	2,100
	1	1,860
	1	1,680
Office Employee	1	1,860
	1	1,020
7. Electrolysis Prevention Section		
Laboratory Employee	1	5,200
	1	3,800
	1	3,300

	I	1,860
	I	900
Shop Employee	I	2,100
Laborer	I	1,200
8. Safety Engineering Section		
Laboratory Employee	I	5,200
	I	3,800
	I	2,900
	2	2,700
Office Employee	I	1,320
9. Electrochemistry Section		
Laboratory Employee	I	3,800
	I	3,300
	I	3,000
	I	2,400
	I	2,100
10. Telephone Service Standards Section		
Laboratory Employee	I	5,200
	I	3,600
	I	3,000
	I	2,400
7. Division of Heat and Power		
Chief of Division	I	5,400
Office Employee	I	2,400
	I	1,800
	I	1,740
	I	1,320
1. Thermometry Section		
Laboratory Employee	I	2,400
	2	1,680
	I	1,500
	I	1,320
	2	1,140
	I	900
2. Pyrometry Section		
Laboratory Employee	I	3,800
	2	3,000
	I	1,860
3. Heat Measurements Section		
Laboratory Employee	I	4,600
	I	4,200
	3	3,800
	I	3,000
	2	2,400
Shop Employee	2	2,100
4. Cryogenic Laboratory Section		
Laboratory Employee	I	3,800
	I	1,860

5. Fire Resistance Section		
Laboratory Employee	1	5,200
	1	3,600
	1	2,500
	1	2,100
	2	1,500
	1	1,140
	2	900
Shop Employee	1	2,000
	1	1,440
	2	1,380
Laborer	1	1,080
	1	900
6. Automotive Power Plants Section		
Laboratory Employee	1	5,200
	1	3,800
	4	3,000
	1	2,700
	1	2,600
	1	2,500
	1	2,400
	2	2,200
	3	2,100
	1	2,000
	2	1,860
	1	1,500
	1	1,140
Shop Employee	1	2,400
	1	2,300
	1	2,100
	1	1,920
	3	1,860
	3	1,740
	1	1,680
	1	1,500
	1	1,380
Laborers	1	1,140
	1	960
8. Optics Division		
Chief of Division	1	5,400
Office Employee	1	1,740
	1	1,500
1. Spectroscopy Section		
Laboratory Employee	1	5,200
	1	3,800
	1	3,000
	2	1,860

2. Polarimetry Section		
Laboratory Employee	1	5,200
	3	3,800
	1	3,300
	1	3,000
	1	2,700
	1	2,400
	3	1,860
	4	1,320
Shop Employee	1	2,100
Office Employee	1	1,860
3. Colorimetry Section		
Laboratory Employee	1	5,200
	1	3,800
	1	3,000
	1	1,860
	1	1,500
	1	1,320
	1	900
Shop Employee	1	2,100
4. Optical Instruments Section		
Laboratory Employee	1	4,200
	1	3,000
	1	2,400
	1	1,860
	2	900
Shop Employee	1	2,300
	2	2,100
	1	1,680
	1	1,500
5. Radiometry Section		
Laboratory Employee	1	5,200
	1	1,860
6. Atomic Physics, Radium, X-Rays Section		
Laboratory Employee	1	5,200
	2	3,800
	1	3,000
	1	2,100
	2	1,860
	1	1,320
Shop Employee	1	1,920
7. Photographic Technology Section		
Laboratory Employee	1	2,800
	2	1,680
	1	1,500
	1	960
	1	900

8. Interferometry Section		
Laboratory Employee	1	3,800
	1	2,400
9. Division of Chemistry		
Acting Chief of Division	1	5,200
Office Employee	1	2,000
	1	1,860
	1	1,740
	1	1,680
	1	1,440
	1	1,020
1. Section of Paint, Varnishes, and Bituminous Materials		
Laboratory Employee	1	3,800
	1	3,000
	5	2,400
	2	1,860
	1	1,680
	1	1,500
2. Section of Detergents, Cement, Corrosion, Etc.		
Laboratory Employee	1	3,800
	2	3,000
	1	2,400
	1	1,860
	1	1,680
	1	1,440
	1	1,140
3. Section of Rubber, Lubricants, Textiles, Inks, Etc.		
Laboratory Employee	1	5,200
	2	3,300
	1	2,900
	2	2,400
	1	1,920
	2	1,860
	1	1,680
	1	1,320
4. Section of Metal and Ore Analysis and Standard Samples		
Laboratory Employee	1	4,400
	1	3,100
	3	3,000
	3	2,400
	1	1,860
Shop Employee	1	1,740
Office Employee	1	1,140

5. Section of Platinum Metals and Reagents		
Laboratory Employee	1	3,800
	1	3,000
	1	2,800
	1	1,320
Office Employee	1	2,040
6. Electrochemistry Section		
Laboratory Employee	1	5,000
	1	3,800
	1	3,000
	1	2,400
	1	1,320
7. Gas Chemistry Section		
Laboratory Employee	1	4,400
	3	3,000
	1	2,500
	1	2,400
	1	2,200
	2	1,860
	1	1,500
Shop Employee	1	2,100
	1	1,680
10. Division of Mechanics and Sound		
Chief of Division	1	5,800
Laboratory Employee	1	5,200
	1	4,000
	1	3,800
	1	900
Shop Employee	1	2,000
Office Employee	1	2,100
1. Section of Engineering Instruments and Mechanical Appliances		
Laboratory Employee	1	3,800
	1	3,000
	1	2,400
	1	1,380
	1	1,140
Shop Employee	1	1,920
2. Sound Section		
Laboratory Employee	1	5,200
	1	3,000
	1	2,400
	1	1,860
	1	960
Shop Employee	1	2,100
	1	1,860
Office Employee	1	1,560
Laborer	1	960

3. Aeronautic Instruments Section		
Laboratory Employee	1	3,800
	1	3,000
	2	2,500
	1	2,400
	1	2,300
	1	2,200
	1	1,920
	1	900
Shop Employee	1	2,300
	2	2,100
Office Employee	1	1,860
4. Aerodynamical Physics Section		
Laboratory Employee	1	3,800
	2	3,000
	1	2,500
	1	1,500
	1	1,320
5. Engineering Mechanics Section		
Laboratory Employee	1	4,200
	2	3,800
	2	3,000
	2	2,400
	1	1,860
	2	1,680
	1	1,440
	2	1,320
	1	900
Shop Employee	1	2,400
	1	1,800
	1	1,680
Office Employee	1	1,320
Laborer	1	960
11. Division of Structural, Engineering, and Miscellaneous Materials		
Chief of Division	1	5,800
Assistant to Chief of Division	1	4,200
Office Employee	1	1,740
	1	1,500
1. Cement, Sand and Stone Section		
Laboratory Employee	1	5,200
	1	3,800
	2	3,000
	1	2,800
	1	2,400
	1	2,000

	6	1,860
	1	1,680
	1	1,140
	1	900
Office Employee	1	1,680
Laborers	1	1,140
	1	1,080
	1	1,020
	1	960
2. Cement, Sand and Stone Section Field Service		
Laboratory Employee, San Francisco, Cal.	1	3,000
	1	1,920
	1	1,560
Laboratory Employee, Denver, Col.	1	2,700
	1	1,560
Laboratory Employee, Northampton, Pa.	1	2,100
	2	1,560
	2	1,500
	1	1,440
	2	1,200
3. Rubber, Leather, etc., Section		
Laboratory Employee	1	4,000
	1	3,300
	1	3,200
	1	3,000
	1	2,800
	1	2,400
	1	1,920
	2	1,860
	1	1,500
	4	1,320
	1	1,200
	1	900
Shop Employee	1	2,100
Office Employee	1	1,560
4. Textile Section		
Laboratory Employee	1	3,800
	1	3,000
	1	2,400
	1	2,300
	2	1,860
	1	1,500
	1	1,140
	2	900
Office Employee	1	1,740

5. Paper Section		
Laboratory Employee	1	3,800
	1	2,800
	1	2,700
	1	2,500
	1	2,400
	1	1,860
	1	1,200
	1	1,140
	1	900
Office Employee	1	1,800
6. Lime, Gypsum, etc., Section		
Laboratory Employee	1	2,400
	4	1,860
Office Employee	1	1,680
12. Metallurgy Division		
Chief of Division	1	5,200
Laboratory Employee	1	3,300
	1	1,920
Office Employee	1	1,860
	1	1,680
	1	1,500
Shop Employee	1	1,920
	1	1,680
1. Optical Metallurgy Section		
Laboratory Employee	1	5,200
	2	2,500
	1	1,860
	1	1,740
	1	1,500
	1	1,380
	1	1,320
	1	1,200
Shop Employee	1	1,680
2. Thermal Metallugy Section		
Laboratory Employee	1	4,200
	2	2,400
	1	2,300
	2	1,320
	1	1,140
Shop Employee	1	1,680
	1	1,500
3. Mechanical Metallurgy Section		
Laboratory Employee	1	3,800
	1	2,400
	1	2,100
	1	1,860

	1	1,500
Laborer	1	1,140
4. Chemical Metallurgy Section		
Laboratory Employee	1	3,800
	1	3,000
	1	2,400
	1	1,500
	2	960
5. Experimental Foundry		
Laboratory Employee	1	3,000
	1	2,500
	1	1,500
	1	1,320
	1	1,140
	1	1,020
Shop Employee	1	1,020
13. Ceramics Division		
The Chief of the Division of Structural, Engineering and Miscellaneous Materials and his assistant supervise the work of this division		
Office Employee	1	1,740
1. Pottery and Fine Ceramics Section		
Laboratory Employee	1	2,800
	2	1,860
	1	1,560
	2	1,140
Shop Employee	2	1,740
2. Optical Glass Section		
Laboratory Employee	1	3,800
	1	3,200
	1	2,400
	1	1,860
	1	1,620
	2	1,500
	1	1,320
Laborer	1	900
3. Clay Products and Refractories Section		
Laboratory Employee	1	3,300
	1	3,000
	1	2,500
	1	2,400
	1	1,920
	1	1,200
Shop Employee	1	1,440
Laborer	1	1,020
4. Enameled Metals Section		
Laboratory Employee	1	2,400
	1	1,920

14. Division of Simplified Practice		
Chief of Division	1	5,400
Simplification Specialist	1	5,400
	2	4,200
	2	3,800
Office Employee	1	3,000
	2	1,680
	1	1,620
	1	1,500
	1	1,380
	1	1,320
	4	1,140
15. Division of Building and Housing		
Chief of Division	1	5,200
Technical Employee	2	3,000
	1	2,500
	2	2,400
Office Employee	1	2,200
	1	2,100
	2	2,040
	1	1,920
	1	1,860
	2	1,740
	1	1,500
	2	1,440
	1	1,380
	1	1,080

APPENDIX 2

CLASSIFICATION OF ACTIVITIES

Explanatory Note

The Classifications of Activities in this series have for their purpose to list and classify in all practicable detail the specific activities engaged in by the several services of the national government. Such statements are of value from a number of standpoints. They furnish, in the first place, the most effective showing that can be made in brief compass of the character of the work performed by the service to which they relate. Secondly, they lay the basis for a system of accounting and reporting that will permit the showing of total expenditures classified according to activities. Finally, taken collectively, they make possible the preparation of a general or consolidated statement of the activities of the government as a whole. Such a statement will reveal in detail, not only what the government is doing, but the services in which the work is being performed. For example, one class of activities that would probably appear in such a classification is that of "scientific research." A subhead under this class would be "chemical research." Under this head would appear the specific lines of investigation under way and the services in which they were being prosecuted. It is hardly necessary to point out the value of such information in planning for future work and in considering the problem of the better distribution and coördination of the work of the government. The Institute contemplates attempting such a general listing and classification of the activities of the government upon the completion of the present series.

Classification of Activities

1. Work in Weights and Measures
    1. Length
    2. Mass

    3. Capacity
    4. Density
    5. Time testing and research
    6. Gas measuring instruments
    7. Thermal expansivity of solids
    8. Investigating and testing commercial scales
    9. Gauge standardization
    10. Weights and measures laws administration
2. Work in Electricity
    1. Resistance measurements
    2. Inductance and capacitance
    3. Electrical measuring instruments
    4. Magnetic measurements
    5. Photometry and illuminating engineering
    6. Electrolysis prevention
    7. Radio communication
    8. Electrical service standards
    9. Telephone service standards
    10. Batteries
3. Safety Engineering
    1. Preparation and revision of safety standards
    2. Investigation of materials and apparatus incidental to safety standards
    3. Coöperation with public and private organizations
4. Heat and Power Measurement and Research
    1. Thermometer laboratory work
    2. High temperature measurements
    3. Heat measurements
    4. Cryogenic laboratory work
5. Investigation of fire resistive properties of building materials
6. Study of automotive power plants, fuels, and lubricants
    1. Automotive engines and accessories
    2. Qualities and characteristics of fuels and lubricants
    3. General performance of automotive vehicles
7. Work in Optics
    1. Spectroscopy
    2. Polarimetry
    3. Colorimetry

    4. Refractrometry and optical instruments
    5. Radiometry
    6. Radioactivity work
    7. X-ray measurements
    8. Atomic properties
    9. Photographic technology
    10. Interferometry
8. Work in Chemistry
    1. Paint, varnish, and bituminous materials
    2. Detergents, cement, and corrosion
    3. Miscellaneous organic materials
    4. Inorganic analysis
    5. Standard samples
    6. Electrochemistry
    7. Gas chemistry
    8. Platinum metals and reagents
9. Work in Mechanics
    1. Engineering instruments and appliances
    2. Aeronautic instruments
    3. Aerodynamical physics
    4. Engineering mechanics
    5. Special investigations
10. Sound measurement
11. Investigation and testing of structural and miscellaneous materials
    1. Cement, concrete, concrete materials, and building stone
    2. Lime, gypsum, and sand-lime brick
12. Investigation and testing of miscellaneous materials
    1. Leather
    2. Rubber
    3. Textiles
    4. Paper
13. Work in metallurgy
    1. Optical metallurgy
    2. Thermal metallurgy
    3. Mechanical metallurgy
    4. Chemical metallurgy
    5. Experimental foundry work

14. Work in Ceramics
    1. Pottery and fine ceramics
    2. Heavy clay products and refractories
    3. Enameled metals
    4. Clays used in paper and textile industries
15. Work in Glass
    1. Glazing and bottle glass
    2. Optical glass
16. Standardization of Equipment
    1. Simplified practice
    2. Preparation of specifications and directory of specifications.
17. Building and Housing Service
    1. Compilation of current statistics
    2. Economic studies
    3. Studies concerning waste elimination
    4. Service to home owners
    5. Technical service to municipalities
    6. Contacts with architectural, trade, and other organizations
18. Rope investigation

APPENDIX 3

PUBLICATIONS

The Bureau of Standards publishes the results of all of its investigational work through the Government Printing Office, and its publications are sold by the Superintendent of Documents. Members of the staff are permitted in certain cases, to publish articles or monographs concerning the results of their work in the technical press.

The Bureau issues an annual report and seven series of publications designated as Circulars, Scientific Papers, Technologic Papers, Handbooks, Simplification Practice Recommendations, Building Code Recommendations, and Miscellaneous Publications. These publications are authorized by the Organic Act of March 3, 1901 (31 Stat. L., 449), which requires the director to make an annual report and authorizes him "to issue, when necessary, bulletins for public distribution containing such information as may be of value to the public or facilitate the bureau in its functions." These publications are technical and reach a limited but strategic group of experts in each field of industry concerned.

An allotment, which in 1924 was $37,000, is annually made for these publications, which are sold through the Superintendent of Documents. Out of its allotment, the Bureau pays for the initial printing of a small edition for free distribution, which is limited to public offices and libraries, educational institutions, scientific societies, and coöperating experts.

The Bureau of Standards began the publication of annual reports when it became a separate bureau, the first report being for the fiscal year ending June 30, 1902. These reports are incorporated in the annual reports of the Secretary of Commerce and are also issued separately. Previous to the creation of the Bureau of Standards the annual reports of the Coast and Geodetic Survey included the reports of the operations of the Office of the Standard Weights and Measures.

The Circulars contain information upon scientific subjects, including methods of testing, the properties of materials, legislation concerning weights and measures, regulations, specifications, and other information of general interest. They appear mostly in the form of pamphlets of under twenty pages each, although a considerable number have been issued containing from twenty to two hundred, and a few over two hundred pages. The Circulars are numbered consecutively, those which have appeared so far being numbered from 1 to 278.

Circular 24 contains a list of the publications of the Bureau of Standards. The seventh edition and a supplement were issued in 1925.

The Scientific Papers, embody the results of the scientific work in reference to standards, instruments, methods of measurement, and physical constants. These also appear in pamphlet form, but are collated and bound about once a year. The bound volumes are termed " Scientific Papers of the Bureau of Standards," superseding, since Volume 14, the " Bulletin of the Bureau of Standards." Each volume contains approximately 750 printed pages. The individual issues of the pamphlet are consecutively numbered, the last number issued being 507. A title-page and index (issued separately) is supplied with the last Scientific Paper of each volume to subscribers for the series.

The Technologic Papers cover the more strictly technologic work. They are also consecutively numbered, the last number issued being 287. Beginning with No. 203, they are collated and bound about once a year. The volumes are uniform in style and size with the Scientific Papers. A title page and index is supplied with each volume as in the case of the Scientific Papers.

The Handbooks consist of a manual of inspection and information for the use of weights and measures officers, and various kinds of safety codes. Five handbooks have been issued, the first being the above-mentioned manual, the others being a national safety code for protection of heads and eyes of industrial workers, a national electrical safety code, a discussion of the national electrical safety code, and an American logging and sawmill safety code.

The Simplified Practice Recommendations contain the results of the studies made by the simplified practice division, the purpose of which is to bring about an elimination of waste in commerce and industry through reduction in the number of sizes and types of standard products. Thirty-three recommendations have been published relating respectively to: Paving bricks; bedsteads, springs and mattresses; metal lath; asphalt; hotel chinaware; files and hasps; face brick and common brick; range boilers and expansion tanks; woven-wire fencing; milk and cream bottles and bottle caps; bed blankets; hollow building tile; structural slate; roofing slate; blackboard slate; lumber; forged tools; builders' hardware; asbestos paper and asbestos millboard; steel barrels and drums; brass lavatory and sink traps; paper; hospital beds; hot water storage tanks; steel reenforcing bars; cotton duck; sheet steel; loaded paper shot shells; concrete building units; chinaware; and steel lockers. Books have also been issued on "Simplified practice: What it is and what it Offers," and "Simplified Practice in Marine Field: Organization of American Marine Standards Committee and its Constitution and Rules."

The Building Code Recommendations contain the results of the Bureau's investigations concerning the framing of local building and plumbing codes, zoning regulations, etc. Seven of these recommendations have been issued.

The Miscellaneous Publications include descriptive pamphlets, tables of equivalents, reports of weights and measures conferences and other material that cannot be classed in any of the other series of publications. Sixty-three numbers of these publications have been issued.

The Scientific Papers and the Technologic Papers are sold by the Superintendent of Documents on subscription and mailed as issued at $1.25 per volume, the foreign subscription price being $2.50 per volume. The pamphlets of each of these two series when collated and bound in cloth, are sold, the Scientific Papers at $2 per annual volume or $2.15 for foreign subscription, and the Technologic Papers at prices which are quoted on application.

Single numbers of all the various publications are sold at prices varying from five cents per copy up, according to the cost of printing and binding.

The Bureau, through its Division of Building and Housing, also issues mimeographed lists of retail prices of building materials as actually paid by contractors for materials delivered on the job in the leading cities of the country.

The Bureau sends out once a month "The Technical News Bulletin" which describes the progress of the work in the laboratories, gives reports of important meetings, lists new publications, etc. This bulletin is sent free to a limited mailing list of government offices and important libraries, and is sold on a subscription basis by the Superintendent of Documents. The issues are numbered serially the last being No. 99, July, 1925.

A "Radio Service Bulletin" is published each month, which contains a classified list of references to the principal radio articles of technical interest appearing in current periodical literature.

A post card giving a list of new publications of the Bureau is issued from time to time.

APPENDIX 4

EQUIPMENT

The nature of the work of the Bureau of Standards is such that almost every section possesses some special equipment designed for the particular class of research or testing in which the section is engaged. Quite a large proportion of this equipment has been designed and constructed by the Bureau, and in other cases it has been made especially for the Bureau's use.

The comparators in the length measurement section, several of the balances in the mass section (one of which will compare two weights with an accuracy of one part in 100 million), the railroad track scale testing equipments, and the gauge testing instruments are all special apparatus of the Weights and Measures Division.

In the Electricity Division may be mentioned the special set-ups for maintaining the fundamental electrical units, the integrating sphere, by which the mean spherical candlepower of a lamp is determined, the magnetic measuring instruments, and numerous pieces of radio equipment.

The Heat and Power Division has special furnaces in which the highest temperatures known on earth can be obtained, and a low temperature laboratory in which a degree of cold but little above absolute zero can be produced. A special laboratory permits the testing of aircraft engines under the conditions existing at high altitudes.

Special devices for analyzing the spectra of elements, for the study of the performance of optical instruments, and for the measurement of length by light waves are to be found in the laboratories of the Optics Division.

The facilities of the Chemistry Division are very complete, the building in which this division is located having been designed especially for this work. The equipment includes all the more usual forms of apparatus as well as special equipment in such fields as gas appliances and electroplating.

The Mechanics and Sound Division is provided with a special tank for testing water current meters; three wind tunnels for its aerodynamic investigations; testing machines for structural materials, the largest of which has a capacity of ten million pounds in compression, and a special building for measuring sound transmission through walls and floors.

The work of the Structural, Engineering, and Miscellaneous Materials Division; the Division of Metallurgy; and the Ceramics Division—all require a study of actual manufacturing processes. Therefore, these divisions include in their equipment a cement plant, rubber mill, textile mill, paper mill, heat treating equipment, complete foundry, a rolling mill, forging press, draw bench, glass plant, etc. Some of this apparatus is of commercial size while other is special small equipment, built especially for research work.

No work is undertaken by the Bureau unless it has or can secure complete laboratory equipment in that particular field.

APPENDIX 5

LAWS

The laws included in this compilation are only those which directly concern the organization and present functions and activities of the Bureau of Standards. There is, in addition, a considerable number of federal laws relating to standards, tests, etc., in connection with the duties and functions of other Bureaus, most of which are mentioned in the history chapter and are referred to in the general index.

(A) Index to Laws

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Supply of sets of, to states and other institutions	5 Stat. L., 133 14 Stat. L., 369 21 Stat. L., 521

(B.) Compilation of Laws

Constitution, Article 1, Section 8, The Congress shall have power to . . . fix the standard of weights and measures.

1836—Joint Resolution of June 14, 1836 (5 Stat. L., 133)—A Resolution Providing for the distribution of weights and measures.[1]

That the Secretary of Commerce be, and he hereby is, directed to cause a complete set of all the weights and measures adopted as standards, and now either made or in the progress of manufacture for the use of the several custom-houses, and for other purposes, to be delivered to the Governor of each State in the Union, or such person as he may appoint, for the use of the States respectively, to the end that an uniform standard of weights and measures may be established throughout the United States.

1866—Joint Resolution of July 27, 1866 (14 Stat. L., 369)—Joint resolution to enable the Secretary of Commerce to furnish to each State one Set of the Standard Weights and Measures of the Metric System.[1]

That the Secretary of Commerce be, and he is hereby, authorized and directed to furnish to each State, to be delivered to the governor thereof, one set of the standard weights and measures of the metric system for the use of the States respectively.

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[1] As modified by acts of February 14, 1903, and March 4, 1913.

1866—Act of July 28, 1866 (14 Stat. L., 339)—An Act to authorize the use of the metric system of weights and measures.

[SEC. 1]. That from and after the passage of this act it shall be lawful throughout the United States of America to employ the weights and measures of the metric system; and no contract or dealing, or pleading in any court, shall be deemed invalid or liable to objection because the weights or measures expressed or referred to therein are weights or measures of the metric system.

SEC. 2. That the tables in the schedule hereto annexed shall be recognized in the construction of contracts, and in all legal proceedings, as establishing, in terms of the weights and measures now in use in the United States, the equivalents of the weights and measures expressed therein in terms of the metric system; and said tables may be lawfully used for computing, determining, and expressing in customary weights and measures the weights and measures of the metric system.

MEASURES OF LENGTH

Metric denominations and values		Equivalents in denominations in use	
Myriameter	10,000 meters.	6.2137	miles.
Kilometer	1,000 meters.	0.62137	miles, or 3280 feet and ten inches.
Hectometer	100 meters.	328	feet and 1 inch.
Dekameter	10 meters.	393.7	inches.
Meter	1 meter.	39.37	inches.
Decimeter	$\frac{1}{10}$ of a meter.	3.937	inches.
Centimeter	$\frac{1}{100}$ of a meter.	0.3937	inches.
Millimeter	$\frac{1}{1000}$ of a meter.	0.0394	inches.

MEASURES OF SURFACE

Metric denominations and values		Equivalents in denominations in use	
Hectare	10,000 square meters.	2.471	acres.
Are	100 square meters.	119.6	square yards.
Centare	1 square meter.	1550	square inches.

MEASURES OF CAPACITY

Metric denominations and values			Equivalents in denominations in use	
Names	Number of Liters	Cubic measure	Dry measure	Liquid or wine measure
Kiloliter, or stere.	1,000	1 cubic meter	1.308 cubic yards	264.17 gallons.
Hectoliter.	100	$\frac{1}{10}$ of a cubic meter	2 bushels and 3.35 pecks.	26.417 gallons.
Dekaliter.	10	10 cubic decimeters	9.08 quarts	2.6417 gallons.
Liter	1	1 cubic decimeter	0.908 quarts	1.0567 quarts.
Deciliter.	$\frac{1}{10}$	$\frac{1}{10}$ of a cubic decimeter	6.1022 cubic inches	0.845 gills.
Centiliter.	$\frac{1}{100}$	10 cubic centimeters	0.6102 cubic inches	0.338 fluid ounces.
Milliliter.	$\frac{1}{1000}$	1 cubic centimeter	0.061 cubic inches	0.27 fluid drams.

WEIGHTS

Metric denominations and values			Equivalents in denominations in use
Names	Number of grams	Weight of what quantity of water at maximum density	Avoirdupois weight
Millier or tonneau	1,000,000	1 cubic meter	2204.6 pounds.
Quintal	100,000	1 hectoliter	220.46 pounds.
Myriagram	10,000	10 liters	22.046 pounds.
Kilogram or kilo	1,000	1 liter	2.2046 pounds.
Hectogram	100	1 deciliter	3.5274 ounces.
Dekagram	10	10 cubic centimeters	0.3527 ounces.
Gram	1	1 cubic centimeter	15.432 grains.
Decigram	$\frac{1}{10}$	$\frac{1}{10}$ of a cubic centimeter	1.5432 grains.
Centigram	$\frac{1}{100}$	10 cubic millimeters	0.1543 grains.
Milligram	$\frac{1}{1000}$	1 cubic millimeter	0.0154 grains.

1881—Joint Resolution of March 3, 1881 (21 Stat. L., 521)—Joint Resolution Authorizing the Secretary of Commerce to furnish States, for the use of agricultural colleges, one set of standard weights and measures and for other purposes.[2]

That the Secretary of Commerce be, and he is hereby, directed to cause a complete set of all the weights and measures adopted as standards to be delivered to the governor of each State in the Union, for the use of agricultural colleges in the States, respectively, which have received a grant of lands from the United States, and also one set of the same for the use of the Smithsonian Institution: That the cost of each set shall not exceed two hundred dollars, and a sum sufficient to carry out the provisions of this resolution is hereby appropriated out of any money in the Treasury not otherwise appropriated.

1890—Act of July 11, 1890 (26 Stat. L., 242)—An Act Making appropriations for the legislative, executive, and judicial expenses of the Government for the fiscal year ending June 30, 1891, and for other purposes.[2]

[SEC. 1]. . . That hereafter such necessary repairs and adjustments shall be made to the standards furnished to the several States and Territories as may be requested by the governors thereof, and also to standard weights and measures that have been, or may hereafter be, supplied to United States custom-houses and other offices of the United States, under act of Congress, when requested by the Secretary of Commerce.

For the construction of standard gallons and their subdivisions for the use of States and Territories which have not received the same, one thousand five hundred dollars.

For purchase of a balance of precision and its mounting, one thousand two hundred dollars.

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[2] As modified by acts of February 14, 1903, and March 4, 1913.

1894—Act of July 12, 1894 (28 Stat. L., 101)—An Act to define and establish the units of electrical measure.

[Sec. 1]. That from and after the passage of this Act the legal units of electrical measure in the United States shall be as follows:

First. The unit of resistance shall be what is known as the international ohm, which is substantially equal to one thousand million units of resistance of the centimeter-gram-second system of electro-magnetic units, and is represented by the resistance offered to an unvarying electric current by a column of mercury at the temperature of melting ice fourteen and four thousand five hundred and twenty-one ten-thousandths grams in mass, of a constant cross-sectional area, and of the length of one hundred and six and three-tenths centimeters.

Second. The unit of current shall be what is known as the international ampere, which is one-tenth of the unit of curent of the centimeter-gram-second system of electro-magnetic units, and is the practical equivalent of the unvarying current, which, when passed through a solution of nitrate of silver in water in accordance with standard specifications, deposits silver at the rate of one thousand one hundred and eighteen millionths of a gram per second.

Third. The unit of electro-motive force shall be what is known as the international volt, which is the electro-motive force that, steadily applied to a conductor whose resistance is one international ohm, will produce a current of an international ampere, and is practically equivalent to one thousand fourteen hundred and thirty-fourths of the electromotive force between the poles or electrodes of the voltaic cell known as Clark's cell, at a temperature of fifteen degrees centigrade, and prepared in the manner described in the standard specifications.

Fourth. The unit of quantity shall be what is known as the international coulomb, which is the quantity of electricity transferred by a current of one international ampere in one second.

Fifth. The unit of capacity shall be what is known as the international farad, which is the capacity of a condenser charged to a potential of one international volt by one international coulomb of electricity.

Sixth. The unit of work shall be the joule, which is equal to ten million units of work in the centimeter-gram-second system, and which is practically equivalent to the energy expended in one second by an international ampere in an international ohm.

Seventh. The unit of power shall be the watt, which is equal to ten million units of power in the centimeter-gram-second system, and which is practically equivalent to the work done at the rate of one joule per second.

Eigth. The unit of induction shall be the henry, which is the induction in a circuit when the electro-motive force induced in this circuit is one international volt while the inducing current varies at the rate of one ampere per second.

Sec. 2. That it shall be the duty of the National Academy of Sciences to prescribe and publish, as soon as possible after the passage of this Act, such specifications of details as shall be necessary for the practical application of the definitions of the ampere and volt hereinbefore given, and such specifications shall be the standard specifications herein mentioned.

1894—Act of August 18, 1894 (28 Stat. L., 383)—An Act Making appropriations for sundry civil expenses of the Government for the fiscal year ending June thirtieth, eighteen hundred and ninety-five, and for other purposes.[3]

[SEC. 1]. . . That hereafter the Secretary of Commerce be, and he is hereby, authorized and directed to furnish precise copies of standard weights and measures bearing the seal of the Bureau of Standards, and accompanied by a suitable certificate, to any State, Territory, or institution heretofore furnished with the same, upon application in writing by the governor in the case of a State or Territory, or by the official head in the case of an institution, setting forth that the copies of standards applied for are to replace similar ones heretofore furnished, in accordance with law, by the office of construction of standard weights and measures of the United States [or Bureau of Standards] which have been lost or destroyed: That the applicant shall, before the said standards are delivered, first deposit with the Secretary of Commerce the amount of money necessary to defray all expenses incurred by the Bureau of Standards in furnishing the same, which amount shall be covered into the Treasury of the United States to the credit of miscellaneous receipts, as soon as the weights or measures are delivered for transportation into the hands of such persons as are designated by the officers ordering the same.

1901—Act of March 3, 1901 (31 Stat. L., 1449)—An Act To establish the National Bureau of Standards.[4]

[SEC. 1]. That the Office of Standard Weights and Measures shall hereafter be known as the National Bureau of Standards.

SEC. 2. That the functions of the bureau shall consist in the custody of the standards; the comparison of the standards used in scientific investigations, engineering, manufacturing, commerce, and educational institutions with the standards adopted or recognized by the Government; the construction, when necessary, of standards, their multiples and subdivisions; the testing and calibration of standard measuring apparatus; the solution of problems which arise in connection with standards; the determination of physical constants and the properties of materials, when such data are of great importance to scientific or manufacturing interests and are not to be obtained of sufficient accuracy elsewhere.

SEC. 3. That the bureau shall exercise its functions for the Government of the United States; for any State or municipal government within the United States; or for any scientific sociey, educational institution, firm, corporation, or individual within the United States engaged in manufacturing or other pursuits requiring the use of standards or standard measuring instruments. All requests for the services of the bureau shall be made in accordance with the rules and regulations herein established.

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[3] As modified by acts of March 3, 1901, February 14, 1903, and March 4, 1913.

[4] As modified by acts of February 14, 1903, and March 4, 1913. An order of the Secretary of Commerce and Labor of July 1, 1903, changed the name to Bureau of Standards.

SEC. 4.[5]

SEC. 5. That the director shall be appointed by the President, by and with the advice and consent of the Senate. He shall have the general supervision of the bureau, its equipment, and the exercise of its functions. He shall make an annual report to the Secretary of Commerce including an abstract of the work done during the year and a financial statement. He may issue, when necessary, bulletins for public distribution, containing such information as may be of value to the public or facilitate the bureau in the exercise of its functions.

SEC. 6. That the officers and employees provided for by this Act, except the director, shall be appointed by the Secretary of Commerce, at such time as their respective services may become necessary.

SEC. 7. [Relates to original appropriations.]

SEC. 8. That for all comparisons, calibrations, tests, or investigations, except those performed for the Government of the United States or State governments within the United States, a reasonable fee shall be charged, according to a schedule submitted by the director and approved by the Secretary of Commerce.

SEC. 9. That the Secretary of Commerce shall, from time to time, make regulations regarding the payment of fees, the limits of tolerance to be attained in standards submitted for verification, the sealing of standards, the disbursement and receipt of moneys, and such other matters as he may deem necessary for carrying this Act into effect.

SEC. 10. That there shall be a visiting committee of five members, to be appointed by the Secretary of Commerce, to consist of men prominent in the various interests involved, and not in the employ of the Government. This committee shall visit the bureau at least once a year, and report to the Secretary of Commerce upon the efficiency of its scientific work and the condition of its equipment. The members of this committee shall serve without compensation, but shall be paid the actual expenses incurred in attending its meetings. The period of service of the members of the original committee shall be so arranged that one member shall retire each year, and the appointments thereafter to be for a period of five years. Appointments made to fill vacancies occurring other than in the regular manner are to be made for the remainder of the period in which the vacancy exists.

1903—Act of February 14, 1903 (32 Stat. L., 826)—An Act To establish the Department of Commerce and Labor, as modified by Act of March 4, 1913 (37 Stat. L., 736).

[SEC. 1.] That there shall be at the seat of government an executive department to be known as the Department of Commerce, and a Secretary of Commerce, who shall be the head thereof. . . .

* * * *

SEC. 4. That the following named . . . bureaus . . . of the public service, now and heretofore under the jurisdiction of the Department of the Treasury, and all that pertains to the same, known as . . . the National Bureau of Standards . . ., be, and the same hereby are transferred from the

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[5] The provisions of this section which related to statutory positions were rendered ineffective by the "Classification Act of 1923," approved March 4, 1923 (42 Stat. L., 1488).

Department of the Treasury to the Department of Commerce and Labor [Commerce], and the same shall hereafter remain under the jurisdiction and supervision of the last-named Department.

1911—Act of March 4, 1911 (36 Stat. L., 1231)—An Act Making appropriation for the legislative, executive, and judicial expenses of the Government for the fiscal year ending June thirtieth, nineteen hundred and twelve, and for other purposes.[6]

Hereafter in the case of the absence of the Director of the Bureau of Standards the Secretary of Commerce may designate some officer of said bureau to perform the duties of the director during his absence.

1911—Act of March 4, 1911 (36 Stat. L., 1354)—An Act To amend Sections thirty-five hundred and forty-eight and thirty-five hundred and forty-nine of the Revised Statutes of the United States, relative to the standards for coinage.

That section thirty-five hundred and forty-eight of the Revised Statutes of the United States be, and the same is hereby, amended so as to read as follows:

"SEC. 3548. For the purpose of securing a due conformity in weight of the coins of the United States to the provisions of the laws relating to coinage, the standard troy pound of the Bureau of Standards of the United States shall be the standard troy pound of the Mint of the United States, conformably to which the coinage thereof shall be regulated."

SEC. 2. That section thirty-five hundred and forty-nine of the Revised Statutes of the United States be, and the same is hereby, amended so as to read as follows:

"SEC. 3549. It shall be the duty of the Director of the Mint to procure for each mint and assay office, to be kept safely thereat, a series of standard weights corresponding to the standard troy pound of he Bureau of Standards of the United States, consisting of a one-pound weight and the requisite subdivisions and multiples thereof, from the hundredths part of a grain to twenty-five pounds. The troy weight ordinarily employed in the transactions of such mints and assay offices shall be regulated according to the above standards at least once in every year, under the inspection of the superintendent and assayer; and the accuracy of those used at the Mint at Philadelphia shall be tested annually, in the presence of the assay commissioners, at the time of the annual examination and test of coins."

1913—Act of March 4, 1913 (37 Stat. L., 736)—An Act To create a Department of Labor.

[SEC. 1.] . . . The Department of Commerce and Labor shall hereafter be called the Department of Commerce, and the Secretary thereof shall be called the Secretary of Commerce, and the act creating the said Department of Commerce and Labor is hereby amended accordingly.

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[6] As modified by act of March 4, 1913.

1913—Act of March 4, 1913 (37 Stat. L., 945)—An Act Making appropriations to provide for the expenses of the Government of the District of Columbia for the fiscal year ending June thirtieth, nineteen hundred and fourteen, and for other purposes.

Hereafter materials for fireproof buildings, other structural materials, and all materials, other than materials for paving and for fuel, purchased for and to be used by the government of the District of Columbia, when necessary in the judgment of the commissioners to be tested, shall be tested by the Bureau of Standards under the same conditions as similar testing is required to be done for the United States Government.

1914—Act of July 16, 1914 (38 Stat. L., 502)—An Act Making appropriations for the legislative, executive, and judicial expenses of the Government for the fiscal year ending June thirtieth, nineteen hundred and fifteen, and for other purposes.

[Sec. 1]. . . Apprentices in the Bureau of Standards may be promoted after satisfactory apprenticeship, with the approval of the Civil Service Commission, to positions corresponding to the journeyman grades for which their duties logically prepare them without regard to apportionment: That they thus acquire no rights to transfer to other lines of work.

1915—Act of March 4, 1915 (38 Stat. L., 1186)—An Act To fix the standard barrel for fruits, vegetables, and other dry commodities.

[Sec. 1]. That the standard barrel for fruits, vegetables, and other dry commodities other than cranberries shall be of the following dimensions when measured without distention of its parts: Length of stave, twenty-eight and one-half inches; diameter of heads, seventeen and one-eighth inches; distance between heads, twenty-six inches; circumference of bulge, sixty-four inches, outside measurement; and the thickness of staves not greater than four-tenths of an inch: That any barrel of a different form having a capacity of seven thousand and fifty-six cubic inches shall be a standard barrel. The standard barrel for cranberries shall be of the following dimensions when measured without distention of its parts; Length of staves, twenty-eight and one-half inches; diameter of head, sixteen and one-fourth inches; distance between heads, twenty-five and one-fourth inches; circumference of bulge, fifty-eight and one-half inches, outside measurement; and the thickness of staves not greater than four-tenths of an inch.

Sec. 2. That it shall be unlawful to sell, offer, or expose for sale in any State, Territory, or the District of Columbia, or to ship from any State, Territory, or the District of Columbia to any other State, Territory, or the District of Columbia or to a foreign country, a barrel containing fruits or vegetables or any other dry commodity of less capacity than the standard barrels defined in the first section of this Act, or subdivisions thereof known as the third, half, and threequarters barrel, and any person guilty of a willful violation of any of the provisions of this Act shall be deemed guilty of a misdemeanor and be liable to a fine not to exceed $500, or imprisonment not to exceed six months, in the court of the United States having jurisdiction: That no barrel shall be deemed below standard within the meaning of this Act when shipped to any foreign country and constructed according to the specifications or directions of the foreign purchaser if not constructed in conflict with the laws of the foreign country to which the same is intended to be shipped.

Sec. 3. That reasonable variations shall be permitted and tolerance shall be established by rules and regulations made by the Director of the Bureau of Standards and approved by the Secretary of Commerce. Prosecutions for offenses under this Act may be begun upon complaint of local sealers of weights and measures or other officers of the several States and Territories appointed to enforce the laws of the said States or Territories, respectively, relating to weights and measures: That nothing in this Act shall apply to barrels used in packing or shipping commodities sold exclusively by weight or numerical count.

Sec. 4. That this Act shall be in force and effect from and after the first day of July, nineteen hundred and sixteen.

1916—Act of August 23, 1916 (39 Stat. L., 530)—An Act To standardize lime barrels.

[Sec. 1]. That there is hereby established a large and a small barrel of lime, the large barrel to consist of two hundred and eighty pounds and the small barrel to consist of one hundred and eighty pounds, net weight.

Sec. 2. That it shall be unlawful for any person to sell or offer for sale lime imported in barrels from a foreign country, or to sell or offer for sale lime in barrels for shipment from any State or Territory or the District of Columbia, to any other State or Territory or the District of Columbia, unless there shall be stencilled or otherwise clearly marked on one or both heads of the small barrel the figures "180 lbs. net" and of the large barrel the figures "280 lbs. net" before the importation or shipment, and on either barrel in addition the name of the manufacturer of the lime and where manufactured, and, if imported, the name of the country from which it is imported.

Sec. 3. When lime is sold in interstate or foreign commerce in containers of less capacity than the standard small barrel, it shall be sold in fractional parts of said standard small barrel, and the net weight of lime contained in such container shall by stencil or otherwise be clearly marked thereon, together with the name of the manufacturer thereof, and the name of the brand, if any, under which it is sold, and, if imported, the name of the country from which it is imported.

Sec. 4. That rules and regulations for the enforcement of this Act, not inconsistent with the provisions of the Act, shall be made by the Director of the Bureau of Standards and approved by the Secretary of Commerce, and that such rules and regulations shall include reasonable variations or tolerances which may be allowed.

SEC. 5. That it shall be unlawful to pack, sell, or offer for sale for shipment from any State or Territory or the District of Columbia to any other State or Territory or the District of Columbia, any barrels or other containers of lime which are not marked as provided in sections two and three of this Act, or to sell, charge for, or purport to deliver from any state or Territory or the District of Columbia to any other State or Territory or the District of Columbia, as a large or small barrel or a fractional part of said small barrel of lime, any less weight of lime than is established by the provisions of this Act; and any person guilty of a violation of the provisions of this Act shall be deemed guilty of a misdemeanor and be liable to a fine not exceeding $100.

SEC. 6 That it shall be the duty of each district attorney, to whom satisfactory evidence of any violation of this Act is presented, to cause appropriate proceedings to be commenced and prosecuted in the United States court having jurisdiction of such offense: That the penal provisions of this Act shall not take effect until January first, nineteen hundred and seventeen.

SEC. 7. That this Act shall be in force and effect from and after its passage.

1918—Act of July 18, 1918 (40 Stat. L., 912)—An Act To provide for the appointment of a commission to standardize screw threads, as amended by Act of March 3, 1919 (40 Stat. L., 1291).

[SEC. 1]. . . That a commission is hereby created, to be known as the Commission for the Standardization of Screw Threads, hereinafter referred to as the Commission, which shall be composed of nine commissioners, one of whom shall be the Director of the Bureau of Standards, who shall be chairman of the commission; two representatives of the Army, to be appointed by the Secretary of War; two representatives of the Navy, to be appointed by the Secretary of the Navy; and four to be appointed by the Secretary of Commerce, two of whom shall be chosen from nominations made by the American Society of Mechanical Engineers and two from nominations made by the Society of Automotive Engineers.

SEC. 2. That it shall be the duty of said commission to ascertain and establish standards for screw threads, which shall be submitted to the Secretary of War, the Secretary of the Navy, and the Secretary of Commerce for their acceptance and approval. Such standards, when thus accepted and approved, shall be adopted and used in the several manufacturing plants under the control of the War and Navy Departments, and, so far as practicable, in all specifications for screw threads in proposals for manufactured articles, parts, or materials to be used under the direction of these departments.

SEC. 3. That the Secretary of Commerce shall promulgate such standards for use by the public and cause the same to be published as a public document.

SEC. 4. That the commission shall serve without compensation but nothing herein shall be held to affect the pay of the commissioners appointed from the Army and Navy or of the Director of the Bureau of Standards.

SEC. 5. That the commission may adopt rules and regulations in regard to its procedure and the conduct of its business.

SEC. 6. That the commission shall cease and terminate at the end of one year and six months from the date of its original appointment.[7]

1925—Act of February 27, 1925 (43 Stat. L., 1014, 1019, 1037, 1039)—An Act Making appropriations for the Departments of State and Justice and for the Judiciary, and for the Departments of Commerce and Labor, for the fiscal year ending June 30, 1926, and for other purposes.

[SEC. 1]. . . International Bureau of Weights and Measures. For contribution to the maintenance of the International Bureau of Weights and Measures, in conformity with the terms of the convention of May 20, 1875, the same to be paid, under the direction of the Secretary of State, to said bureau on its certificate of apportionment, $3,000.

* * * *

Bureau of Standards. Salaries: For the director and other personal services in the District of Columbia in accordance with the Classification Act of 1923, $511,760.

Equipment: For apparatus, machinery, tools, and appliances used in connection with buildings or work of the bureau, laboratory supplies, materials, and supplies used in the construction of apparatus, machinery, or other appliances, including their exchange; piping, wiring, and construction incident to the installation of apparatus, machinery, or appliances; furniture for laboratories and offices, cases for apparatus, $70,000.

General expenses: For fuel for heat, light, and power; office expenses, stationery, books and periodicals, which may be exchanged when not needed for permanent use; traveling expenses (including expenses of attendance upon meetings of technical and professional societies when required in connection with standardization, testing, or other official work of the bureau); street car fares not exceeding $100; expenses of the visiting committee; expenses of attendance of American member at the meeting of the International Committee of Weights and Measures; purchase of gloves, goggles, rubber boots, and aprons; supplies for operation, maintenance, and repair of passenger automobiles and motor trucks for official use, including their exchange; and contingencies of all kinds, $43,500.

Improvement and care of grounds: For grading, construction of roads and walks, piping grounds for water supply, lamps, wiring for lighting purposes and other expenses incident to the improvement and care of grounds, including foreman and laborers in the District of Columbia,

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[7] The term of the National Screw Thread Commission was extended for a period of two years from March 21, 1920, by Joint Resolution of March 23, 1920 (41 Stat. L., 536), and for a period of five years from March 21, 1922, by Joint Resolution of March 21, 1922 (42 Stat. L., 469).

$11,000, of which amount not to exceed $7,740 may be expended for personal services in the District of Columbia.

Testing structural materials: For continuation of the investigation of structural materials, such as stone, clays, cement, and so forth, including personal services in the District of Columbia and in the field, $230,000, of which amount not to exceed $168.180 may be expended for personal services in the District of Columbia, Provided: That as much of this sum as necessary shall be used to collect and disseminate such scientific, practical, and statistical information as may be procured, showing or tending to show approved methods in building, planning, and construction, standardization, and adaptability of structural units, including building materials and codes, economy in the manufacture and utilization of building materials and supplies, and such other matters as may tend to encourage, improve, and cheapen construction and housing.

Testing machines: For maintenance and operation of testing machines, including personal services in connection therewith in the District of Columbia and in the field, for the determination by the Bureau of Standards of the physical constants and the properties of materials as authorized by law, $38,000, of which amount not to exceed $34,020 may be expended for personal services in the District of Columbia.

Investigation of fire-resisting properties: For investigation of fire-resisting properties of building materials and conditions under which they may be most efficiently used, and for the standardization of types of appliances for fire prevention, including personal services in the District of Columbia and in the field, $28,100, of which amount not to exceed $22,640, may be expended for personal services in the District of Columbia.

Investigation of public-utility standards: For investigation of the standards of practice and methods of measurements of public utilities, such as gas, electric light, electric power, water, telephone, central station heating, and electric railway service, and the solution of the problems which arise in connection with standards in such service, including personal services in the District of Columbia and in the field, $100,000, of which amount not to exceed $90,000, may be expended for personal services in the District of Columbia.

Testing miscellaneous materials: For testing miscellaneous materials, such as varnish materials, soap materials, inks, and chemicals, including supplies for the Government departments and independent establishments, including personal services in the District of Columbia and in the field, as authorized by law, $44,090 of which amount not to exceed $42,000, may be expended for personal services in the District of Columbia.

Radio research: For investigation and standardization of methods and instruments employed in radio communication, including personal services in the District of Columbia and in the field, $44,800, of which amount not to exceed $42,200, may be expended for personal services in the District of Columbia.

Color standardization: To develop color standards and methods of manufacture and of color measurement, with special reference to their industrial use in standardization and specification of colorants such as dyestuffs, inks, and pigments, and other products, paint, paper, and textiles, in which color is a pertinent property, including personal services in the District of Columbia and in the field, $9,000, of which amount not to exceed $8,120, may be expended for personal services in the District of Columbia.

Investigation of clay products: To study methods of measurement and technical processes used in the manufacture of pottery, brick, tile, terra cotta, and other clay products, and the study of the properties of the materials used in that industry, including personal services in the District of Columbia, and in the field, $27,000, of which amount not to exceed $20,050, may be expended for personal services in the District of Columbia.

Standardizing mechanical appliances: To develop methods of testing and standardizing machines, motors, tools, measuring instruments, and other apparatus and devices used in mechanical, hydraulic, and aeronautic engineering; for the comparative study of types of apparatus and methods of operation, and for the establishment of standards of performance; for the accurate determination of fundamental physical constants involved in the proper execution of this work; and for the scientific experiments and investigations needed in solving the problems which may arise in connection therewith, especially in response to the requirements of aeronautics and aviation for information of a purely scientific nature, including personal services in the District of Columbia and in the field, $27,800, of which amount not to exceed $25,580, may be expended for personal services in the District of Columbia.

Investigation of optical glass: For the investigation of the problems involved in the production of optical glass, including personal services in the District of Columbia and in the field, $20,520, of which amount not to exceed $14,160, may be expended for personal services in the District of Columbia.

Investigation of textiles: To investigate textiles, paper, leather, and rubber in order to develop standards of quality and methods of measurement, including personal services in the District of Columbia and in the field, $26,560, of which amount not to exceed $23,140, may be expended for personal services in the District of Columbia.

Sugar standardization: For the standardization and design of sugar-testing apparatus; the development of technical specifications for the various grades of sugars, with particular reference to urgent problems made pressing by conditions following the war, especially involving the standardization and manufacture of sugars; for the study of the technical problems incidental to the collection of the revenue on sugar and to determine the fundamental scientific constants of sugars and other substances; for the standardization and production of rare and unusual types of sugars required for the medical service of the Government departments; and for other technical and scientific purposes, including personal services in the District of Columbia and in the field, $38,160, of which amount not to exceed $32,220, may be expended for personal services in the District of Columbia.

Gauge standardization: To provide by coöperation of the Bureau of Standards, the War Department, and the Navy Department for the standardization and testing of the standard gauges, screw threads, and standards required in manufacturing throughout the United States, and to calibrate and test such standard gauges, screw threads, and standards, including necessary equipment and personal services in the District of Columbia and in the field, $38,320, of which amount not to exceed $36,180, may be expended for personal services in the District of Columbia.

Investigation of mine scales and cars: For investigating the conditions and methods of use of scales and mine cars used for weighing and measuring coal dug by miners, for the purpose of determining wages due, and of conditions affecting the accuracy of the weighing or measuring of coal at the mines including personal services in the District of Columbia and in the field, $14,540, of which amount not to exceed $11,340, may be expended for personal services in the District of Columbia.

Metallurgical research: For metallurgical research, including alloy steels, foundry practice, and standards for metals and sands; casting, rolling, forging, and the properties of aluminum alloys; prevention of corrosion of metals and alloys; development of metal substitutes, as for platinum; behavior of bearing metals; preparation of metal specifications; investigation of new metallurgical processes and study of methods of conservation in metallurgical manufacture and products; investigation of materials used in the construction of rails, wheels, axles, and other railway equipment, and the cause of their failure; including personal services in the District of Columbia and in the field, $43,140, of which amount not to exceed $40,080, may be expended for personal services in the District of Columbia.

High temperature investigations: For laboratory and field investigations of suitable methods of high temperature measurements and control in various industrial processes and to assist in making available directly to the industries the results of the bureau's investigations in this field, including personal services in the District of Columbia and in the field, $9,740, of which amount not to exceed $8,460 may be expended for personal services in the District of Columbia.

Sound investigation: For the investigation of the principles of sound and their application to military and industrial purposes, including personal services in the District of Columbia and in the field, $5,580, of which amount not to exceed $5,100, may be expended for personal services in the District of Columbia.

Industrial research: For technical investigations in coöperation with the industries upon fundamental problems involved in industrial development following the war, with a view to assisting in the permanent establishment of the new American industries, including personal services in the District of Columbia and elsewhere, $174,120, of which amount not to exceed $154,000 may be expended for personal services in the District of Columbia.

Testing railroad track and other scales: For investigation and testing of railroad track scales, elevator scales, and other scales used in weighing commodities for interstate shipments and to secure equipment and assistance for testing the scales used by the Government in its transactions with the public, such as post office, navy yard, and customhouse scales, and for the purpose of coöperating with the States in securing uniformity in the weights and measures laws and in the methods of inspection, including personal services in the District of Columbia and in the field, $39,000, of which amount not to exceed $25,460, may be expended for personal services in the District of Columbia.

Standardization of equipment: To enable the Bureau of Standards to coöperate with Government departments, engineers, and manufacturers in the establishment of standards, methods of testing, and inspection of instruments, equipment, tools, and electrical and mechanical devices used in the industries and by the Government, including the practical specifications for quality and performance of such devices, and the formulation of methods of inspection, laboratory, and service tests, including personal services in the District of Columbia and in the field, $110,000, of which amount not to exceed $89,020, may be expended for personal services in the District of Columbia.

Standard materials: For purchase, preparation, analysis, and distribution of standard materials to be used in checking chemical analyses and in the testing of physical measuring apparatus, including personal services in the District of Columbia and in the field, $10,000, of which amount not to exceed $8,000, may be expended for personal services in the District of Columbia.

Investigation of radioactive substances: For an investigation of radioactive substances and the methods of their measurements and testing, including personal services in the District of Columbia and in the field, $10,680, of which amount not to exceed $9,320 may be expended for personal services in the District of Columbia.

Investigation of automotive engines: For the promotion of economy and efficiency in automotive transportation by land and by air through investigations of the basic principles underlying the design, performance, operation, and testing of automotive engines, their fuels, lubricants, accessories, and the power transmitting system used in connection with them, also such elements as brakes and brake linings; to promote economy in the use of liquid fuels and safety in vehicular traffic; including personal services in the District of Columbia and in the field, $25,000, of which amount not to exceed $20,680, may be expended for personal services in the District of Columbia.

During the fiscal year 1926 the head of any department or independent establishment of the Government having funds available for scientific investigations and requiring coöperative work by the Bureau of Standards on scientific investigations within the scope of the functions of that bureau, and which the Bureau of Standards is unable to perform within the limits of its appropriations, may, with the approval of the Secretary of Commerce, transfer to the Bureau of Standards such sums as may be necessary to carry on such investigations. The Secretary of the Treasury shall transfer on the books of the Treasury Department any sums which may be authorized hereunder, and such amounts shall be placed to the credit of the Bureau of Standards for the performance of work for the department or establishment from which the transfer is made.

1925—Act of March 4, 1925 (43 Stat. L., 1313, 1328)—An Act making appropriations to supply deficiencies in certain appropriations for the fiscal year ending June 30, 1925, and prior fiscal years, to provide supplemental appropriations for the fiscal years ending June 30, 1925, and June 30, 1926, and for other purposes.

[SEC. 1] . . . Bureau of Standards. To enable the Secretary of Commerce to acquire by condemnation or otherwise a certain parcel of land described in the Act entitled "An Act authorizing the Secretary of Commerce to acquire, by condemnation or otherwise, a certain tract of land in the District of Columbia for the enlargement of the present site of the Bureau of Standards," approved February 19, 1925, $173,117, to remain available until June 30, 1926.

APPENDIX 6

FINANCIAL STATEMENTS

Explanatory Note

Statements showing appropriations, receipts, expenditures and other financial data for a series of years constitute the most effective single means of exhibiting the growth and development of a service. Due to the fact that Congress has adopted no uniform plan of appropriation for the several services and that the latter employ no uniform plan in respect to the recording and reporting of their receipts and expenditures it is impossible to present data of this character according to any standard scheme of presentation. In the case of some services the administrative reports contain tables showing financial conditions and operations of the service in considerable detail; in others financial data are almost wholly lacking. Careful study has in all cases been made of such data as are available, and the effort has been made to present the results in such a form as will exhibit the financial operations of the services in the most effective way that circumstances permit.

In compiling the financial statement, the figures for the years 1902 to 1909, inclusive, were obtained from the annual reports of the Director of the Bureau of Standards. Those for subsequent years were obtained from the appropriation acts and from the annual "Combined Statement of the Receipts and Disbursements, Balances, etc., of the United States" published by the Treasury Department. All the expenditure figures are on an accrual basis, except that they do not include amounts liquidated after June 30, 1924.

In some instances it was deemed advisable to group in the same column items which appeared separately in the appropriation acts. This was done in the following cases: Under the head of "Equipment, repairs and alterations" are grouped appropriations for apparatus, alterations and repairs, equipment, equipping laboratory, electric laboratory equipment, covering concrete floors physical laboratory, and painting interior walls chemical and physical laboratory, equipping chemical laboratory building, equipping laboratory, freight truck, heating system north laboratory, renewal of storage batteries, repairs power plant, retaining wall and replacement of altitude chambers; under the head of "Laboratories and outbuildings," are included appropriations for laboratory, outbuildings, workshop and storehouse, chemical laboratory, radio laboratory, and retaining wall; "general expenses" include appropriations for general expenses, extra labor installation of equipment in physical laboratory; and "Testing machines" includes appropriations for testing machines, testing machine Pittsburgh, Pennsylvania, and current meter testing tank.

The appropriations and expenditures shown in the column headed "Salaries" in the table include only those covered by the item "Salaries" in the appropriation acts. Nearly double the amounts shown in the table under "Salaries" have been expended in recent years for personal service out of lump sum appropriations made for specific activities, as shown in other columns of the table.

The appropriations include those made directly by Congress, transfers of funds from other departments, and allotments made for the Bureau of Standards from the National Security and Defense Fund. A second table shows in detail the appropriations and expenditures made out of the last-mentioned fund.

BUREAU OF STANDARDS

Appropriations and Expenditures, Fiscal Years, 1902 to 1926, Inclusive

Fiscal year ending June 30	Salaries		Increase of compensation		Building sites		Equipment, repairs and alterations		General expenses	
	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure
1902	$27,140.00	$21,959.76	......	......	$25,000.00	$25,000.00	$10,000.00	$9,915.69	$5,000.00	$4,894.81
1903	36,060.00	32,559.96	......	......	......	......	30,000.00	29,350.00	5,000.00	4,939.97
1904	74,700.00	69,754.59	......	......	......	......	110,000.00	109,172.15	10,925.33	10,876.36
1905	85,780.00	83,932.44	......	......	......	......	78,500.00	78,500.00	13,250.00	13,176.29
1906	99,660.00	95,727.45	......	......	......	......	41,000.00	40,927.61	12,500.00	11,893.51
1907	111,440.00	108,399.59	......	......	......	......	41,000.00	40,502.29	15,000.00	14,995.98
1908	130,620.00	123,874.24	......	......	......	......	41,000.00	40,525.50	15,000.00	14,929.98
1909	141,540.00	138,765.11	......	......	......	......	41,000.00	40,906.27	15,000.00	14,097.20
1910	165,280.00	160,461.01	......	......	......	......	50,000.00	49,754.27	17,500.00	17,271.91
1911	201,440.00	189,552.27	......	......	......	......	46,000.00	45,910.10	19,000.00	18,930.90
1912	236,340.00	224,050.96	......	......	......	......	52,000.00	50,559.39	25,000.00	24,596.18
1913	241,312.66	226,682.95	......	......	85,000.00	68,034.00	77,000.00	75,993.22	25,000.00	24,577.03
1914	290,940.00	270,123.88	......	......	......	......	52,000.00	51,682.14	27,000.00	25,590.71
1915	293,393.33	278,379.16	......	......	......	......	52,000.00	49,886.81	27,000.00	25,874.76
1916	298,780.00	283,079.84	......	......	......	......	90,000.00	87,336.50	27,000.00	26,680.34
1917	311,720.00	289,741.13	......	......	......	......	90,000.00	88,894.11	28,500.00	27,977.78
1918	348,900.00	316,619.03	$28,085.66	$28,085.66	25,000.00	......	72,000.00	70,929.73	35,000.00	33,894.25
1919	432,360.00	374,862.87	60,680.98	60,680.98	......	......	201,000.00	192,567.29	50,000.00	48,654.67
1920	486,760.00	462,457.61	200,646.19	200,646.19	......	......	128,000.00	123,025.43	95,000.00	83,030.64
1921	432,360.00	421,000.24	176,669.21	176,669.21	47,272.00	47,272.00	95,000.00	91,042.86	75,000.00	71,754.35
1922	432,360.00	421,186.70	187,272.76	187,272.76	......	......	95,000.00	77,264.93	75,000.00	64,712.61
1923	432,360.00	[a]414,504.43	180,212.94	180,212.94	......	......	95,000.00	88,635.54	75,000.00	71,301.00
1924	432,360.00	410,155.00	162,392.76	162,392.76	......	......	167,000.00	97,331.28	75,000.00	63,777.12
1925	500,000.00	......	......	......	......	......	71,000.00	......	44,500.00	......
1926	511,760.00	......	......	......	173,117.00	......	70,000.00	......	43,500.00	......

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[a] Of this amount $35,860 were transferred to Salaries, Office of Superintendent, State, War and Navy Department Buildings, 1924.

APPROPRIATIONS AND EXPENDITURES, FISCAL YEARS 1902 TO 1926, INCLUSIVE—*Continued*

Fiscal year ending June 30	Improvement and care of grounds		Laboratories and outbuildings		Testing machines		Color standardization		Determining physical constants	
	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure
1902	......	......	$700,000.00	$699,892.92	......	......	......	......	......	......
1903	......	......	......	......	......	......	......	......	......	......
1904	$500.00	$500.00	......	......	......	......	......	......	......	......
1905	1,000.00	1,000.00	12,500.00	12,487.99	......	......	......	......	......	......
1906	1,500.00	1,499.37	......	......	......	......	......	......	......	......
1907	3,000.00	3,000.00	......	......	......	......	......	......	......	......
1908	3,000.00	2,983.56	......	......	......	......	......	......	......	......
1909	3,000.00	2,997.22	......	......	$180,000.00	$179,870.23	......	......	......	......
1910	3,000.00	2,963.63	......	......	......	......	......	......	......	......
1911	3,000.00	2,785.57	......	......	25,000.00	24,974.95	......	......	......	......
1912	3,000.00	2,892.93	......	......	30,000.00	29,777.92	......	......	......	......
1913	3,000.00	2,986.81	......	......	35,000.00	34,835.66	......	......	......	......
1914	3,000.00	2,997.53	45,000.00	44,964.94	30,080.64	29,997.14	......	......	......	......
1915	6,000.00	5,998.74	200,000.00	197,548.83	30,000.00	29,853.15	......	......	......	......
1916	6,000.00	5,901.11	......	......	33,000.00	32,897.47	......	......	......	......
1917	6,000.00	5,935.67	90,000.00	89,961.85	30,000.00	29,716.27	$10,000.00	$9,727.34	$5,000.00	$4,471.62
1918	6,000.00	5,946.40	......	......	30,000.00	29,382.74	10,000.00	9,666.58	5,000.00	4,994.31
1919	7,500.00	7,285.82	......	......	30,000.00	29,228.77	10,000.00	9,941.50	5,000.00	4,972.18
1920	7,500.00	7,397.95	20,000.00	17,674.27	30,000.00	29,349.95	10,000.00	9,937.25	5,000.00	4,996.00
1921	10,000.00	9,933.51	......	......	30,000.00	29,899.49	10,000.00	9,778.90	......	......
1922	10,000.00	9,690.24	......	......	30,000.00	28,129.16	10,000.00	9,148.48	......	......
1923	10,000.00	9,183.25	......	......	30,000.00	27,082.84	10,000.00	9,693.38	......	......
1924	10,000.00	9,000.00	......	......	35,000.00	32,839.76	10,000.00	9,478.70	......	......
1925	11,460.00	......	......	......	39,460.00	......	10,000.00	......	......	......
1926	11,000.00	......	......	......	38,000.00	......	9,000.00	......	......	......

Appropriations and Expenditures, Fiscal Years 1902 to 1926, Inclusive—*Continued*

Fiscal year ending June 30	Gas-light standards		Gauge standardization		High potential investigation		High temperature investigation		Industrial research	
	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure
1902	......	......	......	......	......	......	......	......	......	......
1903	......	......	......	......	......	......	......	......	......	......
1904	......	......	......	......	......	......	......	......	......	......
1905	......	......	......	......	......	......	......	......	......	......
1906	......	......	......	......	......	......	......	......	......	......
1907	......	......	......	......	......	......	......	......	......	......
1908	......	......	......	......	......	......	......	......	......	......
1909	......	......	......	......	......	......	......	......	......	......
1910	$10,000.00	$9,955.10	......	......	......	......	......	......	......	......
1911	......	......	......	......	......	......	......	......	......	......
1912	......	......	......	......	......	......	......	......	......	......
1913	......	......	......	......	......	......	......	......	......	......
1914	......	......	......	......	$15,000.00	$14,963.71	......	......	......	......
1915	......	......	......	......	15,000.00	14,984.96	......	......	......	......
1916	......	......	......	......	15,000.00	14,949.92	......	......	......	......
1917	......	......	$225,000.00	$222,062.00	15,000.00	14,874.83	......	......	......	......
1918	......	......	......	......	15,000.00	14,604.08	......	......	......	......
1919	......	......	150,000.00	145,116.86	15,000.00	14,817.00	......	......	$50,000.00	$49,544.04
1920	......	......	40,000.00	39,440.39	......	......	$10,000.00	$9,930.92	250,000.00	245,645.94
1921	......	......	[a]42,420.00	40,883.91	......	......	10,000.00	9,963.78	[a]817,877.00	794,513.83
1922	......	......	[a]42,742.94	40,699.29	......	......	10,000.00	9,451.75	[a]461,673.66	432,106.82
1923	......	......	40,000.00	36,246.28	......	......	10,000.00	9,418.00	[a]239,150.00	233,077.20
1924	......	......	40,000.00	36,130.95	......	......	10,000.00	9,377.50	150,000.00	147,307.58
1925	......	......	40,000.00	......	......	......	10,000.00	......	173,820.00	......
1926	......	......	38,320.00	......	......	......	9,740.00	......	174,120.00	......

[a] Includes funds transferred from other departmental accounts.

APPROPRIATIONS AND EXPENDITURES, FISCAL YEARS 1902 TO 1926, INCLUSIVE—*Continued*

Fiscal year ending June 30	Industrial safety standards		Investigating effects of electrical currents		Investigation of automotive engines		Investigation of clay products		Investigation of fire-resisting properties	
	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure
1902	......	......	......	......	......	......	......	......	......	......
1903	......	......	......	......	......	......	......	......	......	......
1904	......	......	......	......	......	......	......	......	......	......
1905	......	......	......	......	......	......	......	......	......	......
1906	......	......	......	......	......	......	......	......	......	......
1907	......	......	......	......	......	......	......	......	......	......
1908	......	......	......	......	......	......	......	......	......	......
1909	......	......	......	......	......	......	......	......	......	......
1910	......	......	......	......	......	......	......	......	......	......
1911	......	......	$15,000.00	$14,859.28	......	......	......	......	......	......
1912	......	......	15,000.00	14,877.31	......	......	......	......	......	......
1913	......	......	10,000.00	9,924.03	......	......	......	......	$25,000.00	$23,640.93
1914	......	......	......	......	......	......	......	......	25,000.00	24,650.37
1915	......	......	......	......	......	......	......	......	25,000.00	24,880.12
1916	......	......	......	......	......	......	......	......	25,000.00	24,921.59
1917	......	......	......	......	......	......	$10,000.00	$9,973.39	25,000.00	24,859.47
1918	......	......	......	......	......	......	10,000.00	9,994.53	25,000.00	24,700.82
1919	......	......	......	......	......	......	20,000.00	19,766.44	25,000.00	24,320.04
1920	$25,000.00	$24,465.82	......	......	......	......	20,000.00	19,817.35	25,000.00	24,495.43
1921	......	......	......	......	......	......	25,000.00	24,518.41	25,000.00	23,082.50
1922	......	......	......	......	......	......	25,000.00	23,431.88	25,000.00	24,190.13
1923	......	......	......	......	......	......	25,000.00	24,648.56	25,000.00	24,168.06
1924	......	......	......	......	$10,000.00	$9,265.00	30,000.00	27,580.46	29,000.00	......
1925	......	......	......	......	25,000.00	......	30,000.00	......	28,100.00	......
1926	......	......	......	......	25,000.00	......	27,000.00	......	......	......

APPROPRIATIONS AND EXPENDITURES, FISCAL YEARS 1902 TO 1926, INCLUSIVE—*Continued*

Fiscal year ending June 30	Investigation of mine scales and cars		Investigation of optical glass		Investigation of public utilities companies		Investigation of public utilities standards		Investigation of radioactive substances	
	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure
1902	......	......	......	......	......	......	......	......	......	......
1903	......	......	......	......	......	......	......	......	......	......
1904	......	......	......	......	......	......	......	......	......	......
1905	......	......	......	......	......	......	......	......	......	......
1906	......	......	......	......	......	......	......	......	......	......
1907	......	......	......	......	......	......	......	......	......	......
1908	......	......	......	......	......	......	......	......	......	......
1909	......	......	......	......	......	......	......	......	......	......
1910	......	......	......	......	......	......	......	......	......	......
1911	......	......	......	......	......	......	......	......	......	......
1912	......	......	......	......	......	......	......	......	......	......
1913	......	......	......	......	......	......	......	......	......	......
1914	......	......	......	......	......	......	......	......	......	......
1915	......	......	......	......	......	......	$25,000.00	$23,230.31	......	......
1916	......	......	......	......	......	......	25,000.00	24,756.29	......	......
1917	......	......	......	......	......	......	40,000.00	39,702.44	......	......
1918	$15,000.00	$14,714.67	$10,121.00	$9,906.08	$50,000.00	$49,280.99	50,000.00	49,942.74	......	......
1919	......	......	20,000.00	17,789.74	......	......	50,000.00	49,420.20	......	......
1920	15,000.00	14,885.81	20,000.00	19,198.35	......	......	85,000.00	84,433.64	......	......
1921	15,000.00	11,763.48	31,000.00	30,837.98	......	......	100,000.00	99,642.12	......	......
1922	15,000.00	13,383.30	28,000.00	26,628.94	......	......	70,000.00	69,293.44	......	......
1923	15,000.00	10,166.96	25,000.00	22,694.40	......	......	85,000.00	83,583.51	$10,000.00	$9,449.25
1924	15,000.00	10,278.17	25,000.00	24,401.54	......	......	95,000.00	87,146.78	10,000.00	8,217.19
1925	15,000.00	......	25,000.00	......	......	......	105,000.00	......	11,000.00	......
1926	14,540.00	......	20,520.00	......	......	......	100,000.00	......	10,680.00	......

APPROPRIATIONS AND EXPENDITURES, FISCAL YEARS 1902 TO 1926, INCLUSIVE—*Continued*

Fiscal year ending June 30	Investigation of railway materials		Investigation of textiles, etc.		Metallurgical research		Military research		Platinum and rare metals	
	Appro-priation	Expen-diture	Appro-priation	Expen-diture	Appro-priation	Expen-diture	Appro-priation	Expen-diture	Appro-priation	Expen-diture
1902	......	......	......	......	......	......	......	......	......	......
1903	......	......	......	......	......	......	......	......	......	......
1904	......	......	......	......	......	......	......	......	......	......
1905	......	......	......	......	......	......	......	......	......	......
1906	......	......	......	......	......	......	......	......	......	......
1907	......	......	......	......	......	......	......	......	......	......
1908	......	......	......	......	......	......	......	......	......	......
1909	......	......	......	......	......	......	......	......	......	......
1910	......	......	......	......	......	......	......	......	......	......
1911	......	......	......	......	......	......	......	......	......	......
1912	......	......	......	......	......	......	......	......	......	......
1913	......	......	......	......	......	......	......	......	......	......
1914	......	......	......	......	......	......	......	......	......	......
1915	$15,000.00	$14,839.06	......	......	......	......	......	......	......	......
1916	15,000.00	14,427.15	......	......	......	......	......	......	......	......
1917	15,000.00	14,856.49	......	......	......	......	$250,000.00	$234,763.92	......	......
1918	15,000.00	14,608.99	......	......	......	......	350,000.00	343,741.54	......	......
1919	15,000.00	14,858.64	$10,000.00	$9,864.91	......	......	......	......	......	......
1920	15,000.00	14,634.36	15,000.00	14,840.44	$25,000.00	$24,500.13	......	......	$15,000.00	$14,982.23
1921	15,000.00	14,751.88	15,000.00	14,887.88	25,000.00	24,854.23	......	......	......	......
1922	......	......	15,000.00	13,957.70	40,000.00	37,487.91	......	......	......	......
1923	......	......	25,000.00	22,413.38	40,000.00	39,605.02	......	......	......	......
1924	......	......	25,000.00	22,518.46	40,000.00	36,229.25	......	......	......	......
1925	......	......	27,000.00	......	44,000.00	......	......	......	......	......
1926	......	......	26,560.00	......	43,140.00	......	......	......	......	......

Appropriations and Expenditures, Fiscal Years 1902 to 1926, Inclusive—*Continued*

Fiscal year ending June 30	Radio research		Refrigerator constants		Rope investigation		Sound investigation		Standard materials	
	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure
1902	......	......	......	......	......	......	......	......	......	......
1903	......	......	......	......	......	......	......	......	......	......
1904	......	......	......	......	......	......	......	......	......	......
1905	......	......	......	......	......	......	......	......	......	......
1906	......	......	......	......	......	......	......	......	......	......
1907	......	......	......	......	......	......	......	......	......	......
1908	......	......	......	......	......	......	......	......	......	......
1909	......	......	......	......	......	......	......	......	......	......
1910	......	......	......	......	......	......	......	......	......	......
1911	......	......	......	......	......	......	......	......	......	......
1912	......	......	......	......	......	......	......	......	......	......
1913	......	......	$15,000.00	$14,883.48	......	......	......	......	......	......
1914	......	......	15,000.00	14,679.60	......	......	......	......	......	......
1915	......	......	15,000.00	14,997.89	......	......	......	......	......	......
1916	$10,000.00	$9,832.25	15,000.00	14,923.23	......	......	......	......	......	......
1917	10,000.00	9,243.60	15,000.00	14,934.19	......	......	......	......	......	......
1918	10,000.00	9,969.04	......	......	......	......	......	......	......	......
1919	20,000.00	19,838.41	......	......	......	......	......	......	$4,000.00	$3,833.34
1920	30,000.00	29,828.42	......	......	......	......	$5,000.00	$4,892.20	5,000.00	4,781.55
1921	30,000.00	29,805.96	......	......	......	......	[a]7,000.00	6,909.68	......	......
1922	30,000.00	28,209.19	......	......	......	......	5,000.00	4,829.31	......	......
1923	30,000.00	29,755.03	......	......	......	......	[a]5,200.00	5,081.02	10,000.00	9,346.18
1924	40,000.00	38,100.61	......	......	$20,000.00	$15,331.03	5,000.00	4,640.00	10,000.00	8,201.29
1925	45,680.00	......	......	......	8,000.00	......	5,580.00	......	10,000.00	......
1926	44,800.00	......	......	......	......	......	5,580.00	......	10,000.00	......

[a] Includes funds transferred from other departmental accounts.

APPROPRIATIONS AND EXPENDITURES, FISCAL YEARS 1902 TO 1926, INCLUSIVE—*Continued*

Fiscal year ending June 30	Standardization of equipment		Standardization of mechanical appliances		Sugar standardization		Testing government materials		Testing miscellaneous materials	
	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure
1902	......	......	......	......	......	......	......	......	......	......
1903	......	......	......	......	......	......	......	......	......	......
1904	......	......	......	......	......	......	......	......	......	......
1905	......	......	......	......	......	......	......	......	......	......
1906	......	......	......	......	......	......	......	......	......	......
1907	......	......	......	......	......	......	......	......	......	......
1908	......	......	......	......	......	......	......	......	......	......
1909	......	......	......	......	......	......	......	......	......	......
1910	......	......	......	......	......	......	......	......	......	......
1911	......	......	......	......	......	......	......	......	......	......
1912	......	......	......	......	......	......	......	......	......	......
1913	......	......	......	......	......	......	......	......	......	......
1914	......	......	......	......	......	......	......	......	......	......
1915	......	......	......	......	......	......	......	......	$20,000.00	$19,920.64
1916	......	......	......	......	......	......	......	......	20,000.00	19,999.96
1917	......	......	$10,000.00	$9,531.62	......	......	......	......	20,000.00	19,892.92
1918	......	......	10,000.00	9,572.83	......	......	......	......	20,000.00	19,974.90
1919	......	......	10,000.00	9,991.79	$20,000.00	$19,423.13	......	......	30,000.00	29,690.30
1920	$52,292.00	$34,394.71	15,000.00	14,242.91	20,000.00	19,256.34	[b]$78,458.46	$78,458.46	30,000.00	29,858.18
1921	15,000.00	9,209.25	[c]35,000.00	34,622.91	30,000.00	29,860.85	21,541.54	20,125.79	30,000.00	29,916.11
1922	[a]100,000.00	88,572.51	15,000.00	[d]13,737.07	30,000.00	28,104.76	......	......	30,000.00	28,409.82
1923	100,000.00	89,926.14	15,000.00	13,980.50	40,000.00	38,816.31	......	......	30,000.00	28,548.95
1924	100,000.00	96,506.28	30,000.00	27,836.70	40,000.00	38,973.33	......	......	40,000.00	38,056.74
1925	110,000.00	......	30,000.00	......	40,000.00	......	......	......	45,260.00	......
1926	110,000.00	......	27,800.00	......	38,160.00	......	......	......	44,090.00	......

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[a] Entire amount transferred from appropriation "Expenses of the Fourteenth Census, 1920-1922."

[b] Original appropriation for 1920 was $100,000, but the 1920 balance was reappropriated for 1921.

[c] Includes funds transferred from other departmental accounts.

[d] Of this amount $1100 was transferred to the "Army Transportation, 1922" account.

APPROPRIATIONS AND EXPENDITURES, FISCAL YEARS 1902 TO 1926, INCLUSIVE—*Concluded*

Fiscal year ending June 30	Testing railroad track and other scales		Testing structural materials		Weights and measures		Printing and binding[b]	
	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure	Allotment	Expenditure
1902	......	......	......	......	......	......	......	......
1903	......	......	......	......	......	......	......	......
1904	......	......	......	......	......	......	......	$2,977.44
1905	......	......	......	......	......	......	......	7,576.41
1906	......	......	......	......	......	......	......	5,451.34
1907	......	......	......	......	......	......	......	9,251.33
1908	......	......	......	......	......	......	......	10,843.13
1909	......	......	......	......	......	......	......	8,360.64
1910	......	......	......	......	$10,000.00	$7,629.90	......	9,982.98
1911	......	......	[a]$73,350.00	$73,158.71	10,000.00	9,081.89	......	15,764.51
1912	......	......	75,000.00	74,929.67	......	......	......	20,475.67
1913	......	......	75,000.00	74,702.78	......	......	$20,000.00	18,278.49
1914	$25,000.00	$24,943.70	75,000.00	74,620.49	......	......	23,000.00	28,033.31
1915	40,000.00	39,821.07	100,000.00	99,759.68	......	......	23,000.00	24,876.38
1916	40,000.00	27,735.24	100,000.00	99,482.93	......	......	23,000.00	35,824.68
1917	44,750.00	44,558.07	100,000.00	99,098.57	......	......	26,000.00	23,649.34
1918	40,000.00	39,869.00	150,000.00	145,742.63	......	......	26,000.00	35,638.74
1919	40,000.00	37,826.10	125,000.00	114,754.27	......	......	30,000.00	32,548.55
1920	40,000.00	39,007.75	125,000.00	122,584.39	......	......	30,000.00	29,930.54
1921	40,000.00	39,471.49	[c]127,250.00	[d]126,179.90	......	......	33,000.00	38,899.38
1922	40,000.00	37,087.14	[c]178,000.00	157,704.06	......	......	35,000.00	30,952.00
1923	40,000.00	38,930.58	175,000.00	173,743.74	......	......	35,000.00	34,101.09
1924	40,000.00	39,020.62	195,000.00	179,555.66	......	......	37,000.00	38,844.19
1925	40,000.00	......	230,000.00	......	......	......	38,000.00	......
1926	39,000.00	......	230,000.00	......	......	......	......	......

[a] Includes a continuous appropriation of $23,350 (all of which was expended) according to "Combined Statement of Receipts and Disbursements of the United States" for 1911 to 1913. This appropriation does not seem to appear in the statute books or in the "Digest of Appropriations."

[b] Allotments from departmental printing fund.

[c] Includes funds transferred from other departmental accounts.

[d] A balance of $367.36 of money transferred from the Reclamation Fund, was returned to that fund, and is not included in expenditure.

Appropriations and Expenditures, National Security and Defense Fund, Fiscal Years 1918 and 1919

Appropriation	Fiscal year ending June 30			
	1918		1919	
	Appropriation	Expenditure	Appropriation	Expenditure
Altitude laboratory	......	......	$60,000.00	$59,897.19
Armament of fortifications, commerce transfer	......	......	224,333.03	145,506.18
Aviation, navy, commerce transfer	......	......	5,000.00	4,998.28
Completing laboratories	......	......	235,000.00	231,870.41
Industrial laboratory	$893,500.00	$883,840.80	......	......
Metallurgical work	100,000.00	99,284.82	......	......
Military researches	......	......	100,000.00	97,362.15
New building	250,000.00	249,947.53	......	......
Power plant equipment (industrial laboratory)	......	......	31,500.00	31,461.01
Production of fabrics	35,000.00	34,298.65	......	......
Production of optical glass	112,762.00	108,293.55	......	......
Roberts' coke oven	45,000.00	31,514.70	40,000.00	39,748.42
Thermite investigation	700.00	655.20	4,300.00	3,946.75
Total	$1,436,962.00	$1,407,835.25	$700,133.03	$614,790.39

APPENDIX 7

BIBLIOGRAPHY[1]

EXPLANATORY NOTE

The bibliographies appended to the several monographs aim to list only those works which deal directly with the services to which they relate their history, activities, organization, methods of business, problems, etc. They are intended primarily to meet the needs of those persons who desire to make a further study of the services from an administrative standpoint. They thus do not include the titles of publications of the services themselves, except in so far as they treat of the services, their work and problems. Nor do they include books or articles dealing merely with technical features other than administrative of the work of the services. In a few cases explanatory notes have been appended where it was thought they would aid in making known the character or value of the publication to which they relate.

After the completion of the series the bibliographies may be assembled and separately published as a bibliography of the Administrative Branch of the National Government.

Agnew, P. G. Work of the Bureau of standards. (In American academy of political and social science, Annals, Mar. 1919, v. 82:278-88)

Benton, Richard. Making weights and measures fair. (In Technical world, Aug. 1912, v. 17:690-93)

Blumm, William. Relation of the Bureau of standards to the printing industry. (In Inland printer, Sept., 1921, v. 67:792)

Branch gage laboratory of the Bureau of standards. (In Machinery, May, 1918, v. 24:830)

—— Same. (In American machinist, May 16, 1918, v. 48:838)

Broadened investigations by the Bureau of standards. (In Engineering record, June 13, 1914, v. 69:665)

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[1] Compiled by Sophy H. Powell.

Brown, F. C. Aviation work of the Bureau of standards. (In Aerial age, Mar. 1923, v. 16: 115-19)

—— Who profits from scientific work? (In Science monthly, Dec. 1924, v. 19: 655-60)

Bureau of standards and the war. (In Nature, May 8, 1919, v. 103: 197-98)

Bureau of standards gage laboratories. (In Mechanical engineering, Mar. 1919, v. 41: 290-91)

Burgess, C. K. Bureau of standards as an educational institution. (In School and society, Sept. 13, 1924, v. 20: 328-32)

—— Governmental research. (In Scientific monthly, Oct. 1920, v. 11: 341-52)

—— National service to industrial managers rendered by the United States bureau of standards. (In Management and administration, Oct. 1923, v. 6: 433-36)

Carhart, H. S. Bureau of standards. (In Popular science monthly, Sept. 1911, v. 79: 209-19)

Change in method of distribution of Bureau of standards standard samples. (In Chemical and metallurgical engineering, Mar. 15, 1919, v. 20: 276)

Corey, Herbert. How one man has saved us millions. (In Collier's weekly, June 9, 1923, v. 71: 7)

Dacy, G. H. Answering a hundred million questions. (In Illustrated world, Aug. 1922, v. 37: 823-26).

Davis, E. C. Where all bluffs are called. (In Collier's weekly, May 23, 1925, v. 75: 38)

Dellinger, J. H. Bureau of standards lends a hand. (In Radio broadcast, Nov. 1922, v. 2: 40-48)

Gives details of Bureau's coöperation with other government departments.

—— Bureau of standards' radio work. (In Federal employee, Oct. 11, 1919, v. 4: 590-93)

Dyer, F. J. Government to the rescue; weights and measures. (In Good housekeeping, Mar. 1911, v. 52: 334-39)

A popular description of the Bureau's field work.

Educational work in the Bureau of standards. (In School and society, June 28, 1919, v. 9: 771-72; v. 10: 398-99)

F. A. Curtis tells about paper laboratories. (In Paper trade journal, Aug. 24, 1922, v. 75: 304)

Fawcett, Waldon. What the National bureau of standards is doing for American municipalities. (In American city, Feb. 1919, v. 20: 154-58)

Fischer, L. A. History of the standard weights and measures of the United States. (In Scientific American supplement, Apr. 14-21, 1906; v. 61: 25310-1; 25334-6)

Franklin institute. Philadelphia. Report . . . on weights and measures . . . Philadelphia, Harding, printer, 1834. 82 p.

Early history of national weights and measures, p. 48-64.

Good work by the bureau physicists. (In Radio broadcast, May, 1914, v. 5: 24)

Good work in the U. S. bureau of standards. (In American machinist, Apr. 28, 1921, v. 54: 741)

Guarding the nation from weight frauds. (In Popular mechanics, Feb. 1924, v. 4: 232-33)

How the Bureau of standards is aiding the builder. (In Concrete, Oct. 1922, v. 21: 99-100)

How Uncle Sam is saving millions for autoists, home-owners and industries. (In Popular mechanics, July, 1924, v. 42: 103-6)

Importance to seal manufacturers [bill for the control and supervision by the federal government of the manufacture of weighing and measuring devices] (In Iron age, June 4, 1914, v. 93: 1435)

Important work of the Bureau of standards. (In Iron age, Jan. 20, 1916, v. 97: 207-8)

Shows the variety of coöperative agencies.

Leadership through industrial research. (In Engineering record, Nov. 25, 1916, v. 74: 639)

Les travaux récents du Bureau of standards des États-Unis. (In Génie Civil, Aug. 2, 1924, v. 85: 105-8)

McBride, R. S. National bureau of standards. (In Chemical and metallurgical engineering, Dec. 13, 1922, v. 27: 1159-64)

Contains organization chart.

Mendenhall, T. C. Legislation relating to standards. (In Science, July 3, 1896, n. s. v. 4: 1-8)

Merrill, A. S. Bureau of standards. (In Technology review, Oct. 1904, v. 6: 576-81)

—— Same. Boston, Ellis [printer] 1904. 8 p.

Morrow, J. B. Samuel Wesley Stratton made science pay dividends. (In Nation's business, Dec. 1922, v. 10: 21-23)

Nation's research laboratory. (In Scientific American, July 8, 1916, v. 115: 42-43)

Coöperation of the Bureau with industries.

Need of a national standardization bureau. (In Scientific American, May 19, 1900, v. 82: 307)

Nicholas, Frederic. Development of the Bureau of standards. (In Electrical world, Dec. 4, 1915, v. 66: 1244-8)

Details of growth and organization.

—— Electrical work of the Bureau of standards. (In Electrical world, Dec. 18, 1915, v. 66: 1359-62)

Paper work of the Bureau of standards. (In Paper, Jan. 18, 1922, v. 29: 12-15, 20)

Priest, I. G. Work of the national Bureau of standards on the establishment of color standards and methods of color specification. (In *Illuminating engineering society,* Transactions, Feb. 11, 1918, v. 13: 38-49)

Pritchett, H. S. Story of the establishment of the National Bureau of standards. (In Science, Feb. 21, 1902, n. s. v. 15: 281-84)

Public utilities work of the Bureau of standards. (In Electrical world, Dec. 19, 1914, v. 64: 1187-88)

Relation of Bureau of standards to state commission. (In Electrical world, Nov. 8, 1913, v. 62: 941-42)

Relation of federal bureaus to textile industry. (In Textile world, Dec. 16, 1922, v. 62: 3425-26, 3467)

Research work of the United States bureau of standards. (In Scientific American monthly, Jan. 1920, v. 1: 93-95)

Reverchon, Leopold. Les laboratoires nationaux d'industrie, le Bureau of standards de Washington. (In La Nature, 13 Oct. 1917, no. 2298: 225-31)

Rise of the Bureau of standards. (In Scientific American, Mar. 25, 1916, v. 114: 320)

Rosa, E. B. Bureau of standards and industrial standardization. (In American federationist, Nov. 1919, v. 26: 1029-32)

—— National Bureau of standards and its relation to scientific and technical laboratories. (In Science, Feb. 3, 1905, n. s. v. 21: 161-74)

—— Relation of the Bureau of standards to the public service commission. (In Electrical review and western electrician, Jan. 31, 1914, v. 64: 239-40)

—— What the national Bureau of standards is doing. (In Electrical world, Sept. 4, 1915, v. 66: 527)

—— Work of the Electrical division of the Bureau of standards. (In Science, Jan. 5, 1912, n. s. v. 35: 8-19)

Stratton, S. W. Bureau of standards and its relation to the United States Coast and geodetic survey. 1916. 18 p.

Reprinted from Centennial celebration of Coast and geodetic survey, Apr. 5-6, 1916. p. 25-40.

—— Bureau of standards and the machine building industry. (In American machinist, Dec. 6, 1917, v. 47: 976-77)

—— National Bureau of standards. Boston? National association of wool manufacturers. 1902. 8 p.

—— National Bureau of standards. (In Journal of Franklin institute, Feb. 1902, v. 153: 81-92)

—— National Bureau of standards. (In *Pan American union,* Bulletin, Spanish edition, Mar. 1923, v. 56: 227-43)

—— National Bureau of standards and its work. (In Scientific American supplement, Oct. 21, 1911, v. 72: 264-66)

—— Relation of Bureau of standards to the development of engineering. (In *American society* of *mechanical engineers,* Journal, Jan. 1915, v. 37: 38-40)

—— Six stories of farsighted research. (In Independent, May 29, 1920, v. 102: 280,306,307)

—— Work of the national bureau of standards; address before the Engineers' club of Dayton, Ohio, May 4, 1915. Dayton? No publisher. 1915. 52 p.

—— Work of the National Bureau of standards, paper read before National association of cotton manufacturers, Apr. 26-27, 1916. Boston? No publisher. 1916. 43 p.

—— Work of the United States national Bureau of standards. (In Pan American scientific congress, Proceedings, 1915-1916, v. 6: 397-404)

—— and Rosa, E. B. National Bureau of standards. (In American institute of electrical engineers, Transactions, 1905, v. 24: 1039-90)

—— Same. Printed as separate.

Textiles and Bureau of standards. (In Textile world, Sept. 30, 1922, v. 62: 1782)

Coöperation with textile industries and government department explained.

Towne, H. R. Weights and measures commission. (In Engineering magazine, Jan. 1907, v. 32: 630-32)

U. S.[1] *Budget bureau.* Supplemental estimate of appropriation for Department of commerce [for investigation of performance of automotive power plants, etc. Bureau of standards] fiscal year 1924. 1924. 2 p.

(68th Cong. 1st sess., House doc. 190.)

—— *Bureau of education.* Advanced educational work within government bureau. [Standards] by P. G. Agnew. 1919. 7 p.

(Higher educational circular 14.)

—— —— Lessons in community and national life . . . national standards and the Bureau of standards [prepared by E. B. Rosa and H. G. Moulton] 1918. 32 p.

—— *Bureau of standards.* Annual report of director, 1904-date.

---

[1] All entries under U. S. published by Government Printing Office, Washington, D. C., unless otherwise specified.

—— —— Circular of information of national bureau of standards, no. 1-4, 1902-03.

Circular 1 is announcement of organization.

—— —— Elimination of waste: simplified practice, what it is and what it offers, summary of activities of Division of simplified practice and description of services offered to American industries [with bibliography on simplification]. 1924. 33 p.

Bibliography; p. 28-33.

—— —— History of standard weights and measures of the United States by L. A. Fischer. (In Bulletin of Bureau of standards, 1904-1905, v. 1:365-81)

Also published separately.

—— —— Laws concerning the weights and measures of the United States compiled by L. A. Fischer and H. D. Hubbard. 1904. 476 p.

—— —— Same. Second edition, "State and national laws concerning weights and measures of the United States." 1912. 564 p.

—— —— Manual of inspection and information for weights and measures officials, by F. S. Holbrook. . . . 1918. 246 p.

(Bureau of standards, miscellaneous publications no. 1.)
Appendix contains federal laws.

—— —— National bureau of standards, by S. W. Stratton, 1911. 24 p.

—— —— National bureau of standards . . . by S. W. Stratton. 1912. 19 p.

—— —— Report of Board of visitors to Bureau of standards, 1918. 4 p. (65th Cong. 3d sess. House doc. 1603)

Serial 7582

—— —— Rules and regulations for the enforcement of lime barrel act. 1917. 6 p.

(Circular of Bureau of standards 71.)

—— —— Simplified practice in marine field; organization of American marine standards committee and its constitution and rules. 1924. 18 p.

—— —— Supplementing exhibit of Bureau of standards at Brazil centennial exposition . . . 1922-23, by W E. Emley, 1922. 14 p.

—— —— Same. In Spanish. 13 p.

—— —— War work of Bureau of standards, Apr. 1, 1921. 1921. 299 p.

(Miscellaneous publication 46.)

—— *Commerce and labor department.* Estimate of appropriation for collection of information in relation to weights and measures Mar. 14, 1910. 1910. 2 p. (61st Cong. 2d sess. House doc. 777) Serial 5836

—— —— Estimate of appropriation for investigations [on refrigeration] to be made by Bureau of standards. May 24, 1912. 1912. 2 p. (62nd Cong. 2d sess. House doc. 766) Serial 6326

—— *Commerce department.* Appropriation for radio laboratory Bureau of standards. . . . July 30, 1917. 1917. 3 p. (65th Cong. 1st sess. House doc. 297) Serial 7300

—— —— Appropriation required for standardization of equipment . . . Bureau of standards, fiscal year, 1921. Jan. 17, 1921. 1921. 2 p. (66th Cong. 3d sess. House doc. 983) Serial 7913

—— —— Estimates of appropriations, Bureau of standards, May 24, 1919. 1919. 4 p. (66th Cong. 1st sess. House doc. 56) Serial 7645

—— —— Supplemental estimates of appropriation, Bureau of standards . . . fiscal year 1920. 1919. 3 p. (66th Cong. 1st sess. House doc. 151) Serial 7645

—— *Congress. Select committee to investigate weights and measures.* Investigation . . . 1842. Philadelphia, U. S. job printing office, [printers]. 1843. 63 p.

Weights and measures, pp. 45-63.
An itemized detailed history of the origin of the office of weights and measures, written by Mr. Hassler.

—— —— *House. Committee on appropriations.* Departments of commerce and labor appropriation bill. Hearings, 1923-date. 1922-date.

See Standards bureau in index to each volume.

—— —— —— —— Hearings . . . on legislative, executive and judicial appropriation bill, 1903-1922.

See Standards bureau in index to each volume.

—— —— —— —— Sundry civil appropriation bill. Hearings, 1908-1922.

See Standards bureau in index to each volume.

—— —— —— *Committee on coinage, weights and measures.* Hearings . . . May 3, 1900 [upon H. D. 625, 56th Congress, 1st session. Draft of a bill for establishment of national standardizing bureau of enlarging functions of office of standard weights and measures] 1900. 57 p.

—— —— —— —— Hearing . . . on H. R. 5956, H. R. 1741, H. R. 17822 and H. R. 17936 [to establish various standards of baskets and scales]. 1912. 42 p.

—— —— —— —— Hearings . . . on H. R. 9323, Feb. 10, 1916. 1916. 22 p.

—— —— —— —— Hearings . . . on H. R. 10472 [to establish commission to standardize screw threads]. Mar. 5 and 7, 1918. 1918. 35 p.

—— —— —— —— National standardizing bureau. [Report, favoring H. 11350 to establish national bureau of standards]. May 14, 1900. 1900. 2 p. (56th Cong. 1st sess. House rept. 1452) Serial 4026

—— —— —— —— Regulations and control of manufacture, sale and use of weights and measures. Hearings . . . on H. R. 9323. Feb. 10 and May 11, 1916. 1916. 34 p.

—— —— —— —— Standardization of weights and measures used in trade and commerce, hearings on H. R. 4465 . . . Mar. 28 and Apr. 4, 1924. 1924. 2 vols.

—— —— —— *Committee on commerce.* Report on standard weights and measures, Jan. 30, 1836 [to furnish standards to states]. 1836. 2 p. (24th Cong. 1st sess. House rept. 259) Serial 293

—— —— —— —— Report on standard weights and measures, Mar. 21, 1836 [that they be furnished to states and territories] 1836. 2 p. (24th Cong. 1st sess. House rept. 449) Serial 294

—— —— —— *Committee on interstate and foreign commerce.* Original investigation and research concerning forms and processes of manufacture. Report . . . Feb. 16, 1916 [to accompany H. R. 4724] 1916. 1 p. (64th Cong. 1st sess. House rept. 203) Serial 6903

—— —— —— *Select committee on weights and measures.* Report . . . upon fixing a standard of weights and measures, Jan. 25, 1819. [Washington] 1819. 12 p. (15th Cong. 2d. sess. House doc. 109) Serial 22

—— —— —— —— Report . . . upon weights and measures, Mar. 11, 1822. 1822. 4 p. (17th Cong. 1st sess. House rept. 65) Serial 70
Recommendation based upon the report of John Quincy Adams, 1821, which see under *U. S. State department.*

—— —— —— —— Report, Feb. 27, 1835. 1835. 31 p. (23d Cong. 2d sess. House rept. 132) Serial 276

—— —— *Senate. Committee on commerce.* Report . . . favoring S. 4680, to establish national standardizing bureau, Dec. 28, 1900. 1901. 57 p. Serial 4033
Also published as Senate doc. 70, 56th Cong. 2d sess.

—— *National bureau of standards.* Annual reports, 1901-1903.

Before 1901, the annual reports appeared as part of the reports of the Coast and geodetic survey.

—— *President.* (Wilson) Executive order no. 2715 [authorizing Secretary of commerce to appoint to competitive classified service selected staff of 28 employees who have been engaged upon work of important military nature, which will in future be carried on in new division of Bureau of standards]. Sept. 27, 1917. [1917]. 1 p.

—— *State department* (J. Q. Adams, secretary) Report relating to weights and measures, Feb. 22, 1821. 1821. 245 p. (16th Cong. 2d sess. House doc. 109) Serial 55

This is an important document in the history of the movement toward standardization.

—— —— (Thomas Jefferson, secretary). Plan for establishing uniformity in the coinage, weights and measures of the United States, July 13, 1790. (In American state papers, Class X, Miscellaneous, 1789-1809, v. 1 : 13-20)

—— —— Report of secretary of state on the subject of establishing a uniformity in the weights, measures and coins of the United States. . . . New York, Childs and Swaine [printers]. 1790. 49 p.

—— *Superintendent of Coast Survey and of weights and measures.* Documents relating to the construction of uniform standards of weights and measures for the United States 1832-1835, by F. R. Hassler, Superintendent of the work, New York, Windt [printer] 1836. 25 p.

—— —— Documents relating to construction of standard for weights and measures for the custom houses from March to November, 1835. New York, Van Norden [printer] 1835. 25 p.

—— —— Letter . . . concerning construction of standard weights and measures, Nov. 17, 1840. 1840. 8 p. (26th Cong. 2d sess. House doc. 14) Serial 382

Weights and measures, p. 7-8.

—— —— Letter . . . relative to standard weights, July 3, 1838. 1838. 6 p. (25th Cong. 2d sess. House doc. 454) Serial 331

—— —— Letter . . . upon progress of preparing standard weights and measures, Dec. 30, 1839. 1839? 8 p. (26th Cong. 1st sess. House doc. 20) Serial 364

Weights and measures, p. 6-8.

—— —— Letter upon progress which has been made in the fabrication of standard weights and measures. 1837. 16 p. (25th Cong. 2d sess. House doc. 14) Serial 322

Weights and measures, p. 5-16.

—— —— Report . . . on standards for states. Nov. 15, 1838. 1838. 7 p. (25th Cong. 3d sess. senate doc. 4) Serial 338

—— —— Report on standards for states, July 14, 1840. 1840. 6 p. (26th Cong. 1st sess. House doc. 261) Serial 369

—— —— Report on weights and measures in custom houses. June 20, 1832. Washington, Duff Green [printer] 1832. 122 p. (22d Cong. 1st sess. Senate doc. 168) Serial 214

—— —— Same, also printed as House doc. 299 of same Congress. Serial 221

—— —— Report upon completion of standard ounce weights for all the states of the union. June 22, 1841. 1841. 4 p. (27th Cong. 1st sess. House doc. 33) Serial 392

—— —— Report upon construction and completion of standards of weights and measures for the different states. Nov. 16, 1839. 1839. 2 p. (26th Cong. 1st sess. Senate doc. 15) Serial 353

—— —— Report . . . for 1846-47, [with history of standardization to date]. 1848. 29 p. (30th Cong. 1st sess. House ex. doc. 84) Serial 522

—— —— Same, published as Senate Ex. doc. 73, 30th Cong. 1st sess. Serial 510

—— —— Report on construction of standard weights, measures and balances for 1844. 1844. 32 p. (28th Cong. 2d sess. House doc. 159) Serial 466

—— —— Same, published as Senate doc. 149, 28th Cong. 2d sess. Serial 457

—— —— Report . . . on the progress of construction of metric standards for the states. Washington? 1869. 4 p.

—— —— Report on weights and measures, Aug. 7, 1846. 1846. 23 p. (29th Cong. 1st sess. House doc. 225) Serial 486

Refers to distribution of standards to states.

—— —— Report on weights and measures. 1856. 218 p. (34th Cong. 3d sess. Senate Ex. doc. 27) Serial 879

Known as the 1856 report. Contains considerable historical data.

—— —— Third volume of the principal documents relating to construction of uniform standards of weights and measures for customs houses and states . . . by F. R. Hassler. New York, Windt [printer]. 1836. 123 p.

—— *Treasury department.* Letter of the Secretary on standard weights and measures, Dec. 26, 1835, transmitting information in relation to a standard of weights and measures. (34th Cong. 1st sess. House Ex. doc. 32) Serial 287

—— —— Letter . . . transmitting a draft of a bill for the establishment of a national standardizing bureau. April 18, 1900. 1900. 11 p. (56th Cong. 1st sess. House doc. 625) Serial 3997

United States Bureau of standards and engineering abroad. (In Scientific American, Apr. 1, 1916, v. 114: 356)

Uzzell, T. H. Science on the job; how the Bureau of standards is helping American industry. (In Everybody's magazine, Aug. 1919, v. 41: 66-69, 90)

Vernon, L. T. National Bureau of standards. (In World today, June, 1904, v. 6: 757-64).

Wade, H. T. National Bureau of standards and standards for public utilities. (In Engineering magazine, May, 1915, v. 49: 240-51)

—— Uncle Sam as weigher, tester and measurer. (In Review of reviews, Mar. 1916, v. 53: 321-28)

—— United States national Bureau of standards. (In Engineering magazine, Oct. 1908, v. 36: 1-22)

—— United States National Bureau of standards. (In Scientific American, Dec. 2, 1905, v. 93: 437)

Walen, E. D. Bureau of standards research laboratories. (In Textile world, Mar. 8, 1919, v. 55: 1563-65)

War work of the Bureau of standards, U. S. A. (In Nature, Dec. 22, 1921, v. 108: 540-41)

Webster, A. G. Bureau of standards. (In Science, Aug. 11, 1922, n. s. v. 56: 170-71)

What the Bureau of standards can do for you. (In Factory, May, 1922, v. 28: 540-41, 554, 556, 558)

Winters, S. R. Uncle Sam's question and answer office. (In Scientific American, Aug. 1923, v. 129: 114)

Wolff, F. A. Relation of the Bureau of standards to physical research. (In National educational association, Proceedings, 1916: 713-16)

Work of the Bureau of standards. (In Machinery, Feb. 1920, v. 26: 505-08)

Work of the Bureau of standards. (In Machinery, Feb. 1923, v. 29: 439)

Work of the Bureau of standards. (In Science, Mar. 29, 1912, n. s v. 35: 514-15)

BIBLIOGRAPHY

U. S. Bureau of Standards. Publications of Bureau of Standards. 6th ed. July 1, 1922. 182 p. Supplement. Jan. 1924. 49 p.

(Circular of Bureau of Standards 24.)

—— *Coast and geodetic survey.* Descriptive catalogue of publications relating to survey, 1807-1896, and to standard weights and measures, 1790-1896. 1898. 118 p.

(Special publication 2.)

—— —— Coast and geodetic and weights and measures. Report, 1891. 1892. 2 pts. (52d Cong., 1st sess. House Ex. doc. 43) Serial 2952

Descriptive catalogue of publications relating to weights and measures standards, 1807-1890; Pt. 2: 365-474.)

—— *Superintendent of documents.* Standards of weights and measures: tests of metals, etc., . . . publications for sale by superintendent of documents. 1925. 40 p.
(Price list 64, 10th ed.)
This gives an idea of the material published by the Bureau of standards.

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